SEVENTH FRAMEWORK PROGRAMME
Challenge 1
Information and Communication Technologies

Trusted Architecture for Securely Shared Services

Document Type:	Deliverable
Title:	**TAS³ Architecture**
Work Package:	WP2
Deliverable Nr:	D2.1
Dissemination:	Public
Preparation Date:	8th July, 2011
Version:	2.24

The TAS³ Consortium

	Beneficiary Name	Country	Short	Role
1	KU Leuven	BE	KUL	Project Mgr
2	Synergetics NV/SA	BE	SYN	Partner
3	University of Kent	UK	KENT	Partner
4	University of Karlsruhe	DE	KARL	Partner
5	Technische Universiteit Eindhoven	NL	TUE	Partner
6	CNR/ISTI	IT	CNR	Partner
7	University of Koblenz-Landau	DE	UNIKOL	Partner
8	Vrije Universiteit Brussel	BE	VUB	Partner
9	University of Zaragoza	ES	UNIZAR	Partner
10	University of Nottingham	UK	NOT	Partner
11	SAP Research	DE	SAP	Coordinator
12	EIfEL	FR	EIF	Partner
13	Intalio	UK	INT	Partner
14	Risaris	IR	RIS	Partner
15	Kenteq	NL	KETQ	Partner
16	Oracle	UK	ORACLE	Partner
17	Custodix	BE	CUS	Partner
18	Medisoft	NL	MEDI	Partner
19	KIT	DE	KARL	Partner
20	Symlabs	PT	SYM	Partner

Contributors

	Name	Organisation
1	Joseph Alhadeff	Oracle
2	Brendan Van Alsenoy	KUL
3	Guglielmo De Angelis	CNR/ISTI
4	Michele Bezzi	SAP
5	David Chadwick	KENT
6	Brecht Claerhout	CUS
7	Danny De Cock	KUL
8	Marc Van Coillie	EIF
9	Elisa Costante	TUE
10	Ioana-Georgiana Ciuciu	VUB
11	Carlos Flavian	ZAR
12	Michal Guinaliù	ZAR
13	Seda Gürses	KUL
14	Ingo Dahn	UNIKOLD
15	Thorsten Haberecht	KARL
16	Jerry den Hartog	TUE
17	Jeroen Hoppenbrouwers	SYN
18	Sampo Kellomäki (main contributor)	SYN
19	Thomas Kirkham	NOT
20	Michael Kutscher	UNIKOLD

	Name	Organisation
21	Keqin Li	SAP
22	Stijn Lievens	KENT
23	Gilles Montagnon	SAP
24	Jutta Mülle	KARL
25	Jens Müller	KARL
26	Jean-Christophe Pazzaglia	SAP
27	Lex Pohlman	KENTEQ
28	Quentin Reul	VUB
29	Brian Reynolds	RIS
30	Marc Santos	UNIKOLD
31	Luis Schilders	CUS
32	Magali Seguran	SAP
33	Silvia von Stackelberg	KARL
34	Slim Trabelsi	SAP
35	Luk Vervenne	SYN
36	Sara Winfield	NOT
37	Gang Zhao	VUB

Contents

List of Figures

Keyword List

Architecture, Security, Trust, Privacy

Architecture Executive Summary

This document contains version 2 of the TAS³ system architecture (by system architecture we mean the conceptual design that defines the structure and behaviour of a TAS³ trust network). As the Description of Work states, the TAS³ project's main objective is to provide a next generation trust & security architecture that is ready to (1) meet the requirements of complex and highly versatile business processes, (2) enable the dynamic user-centric management of policies and (3) ensure end-to-end secure transmission of personal information and user- controlled attributes between heterogeneous, context dependent and continuously changing systems. This architecture has been designed to fulfil the above objectives through a combination of:

- providing users with the ability to meaningfully give their consent to the use of their personal information
- ensuring a complete set of audit information is recorded by a TAS³ trust network and that users have the ability to directly or indirectly see the audit information that pertains to their personal information. Note that there will not be a single central audit log that contains all the information. Instead the central audit log will only contain summary information. If a person needs to drill down into the distributed audit trail, he will need to be authorised and obtain sufficient permissions to access the various local audit logs.
- a legal framework and set of model contracts that will contractually bind all service providers into
- operating in a trustworthy manner e.g. so as to honour the choices of users concerning the handling of their personal information
- a set of trusted third parties that facilitate the sharing of trust related information such as public keys, authorization attributes, and reputation information
- strong cryptographic algorithms and privacy preserving protocols
- end to end security through application layer encryption and digital signing
- sticky policies that cryptographically bind data and policies together, along with a policy enforcement infrastructure that controls access to all resources
- quality assurance and testing technology and actors to test if on-line services actually behave in compliance with their specifications.

This architecture document describes the conceptual entities that are needed and the services they should provide in order to operate a TAS³ trust network. These trust and privacy enhancing services include: authorization services, secure business process management services, delegation services, privacy preserving discovery services, identity management services, secure repository services and trust and reputation services. All of these services are usually needed regardless of the applications that might run in a TAS³ trust network. However, small centralized trust networks may be able to dispense with one or more of these

trust and privacy enhancing services, e.g. discovery or delegation services, depending upon their requirements.

This architecture contains many novel features such as: a trust infrastructure based on novel metrics, actor behaviour and structural components which can be correlated together, an authorisation infrastructure which supports multiple policy languages and conflict resolution, an obligation infrastructure which enforces privacy throughout the trust network, and a distributed audit system which can be cross correlated via a central summary audit system operated by the trusted network provider. These are described in more detail in the specific work package deliverables.

The TAS³ architecture is designed to be standards, protocol, data and application agnostic so that any protocol capable of implementing the flows and satisfying the service requirements can potentially be used by any application.

Annex A lists the events that should be captured in the secure audit trails of a TAS³ trust network

Annex B summarizes the threats that the TAS³ architecture is designed to protect against

Annex C summarises the user centricity of TAS³.

Scope. The TAS³ project has a narrower scope than the architecture that is documented here. This is natural as the novel research contributions of TAS³ are being made only in some areas of the architecture. However the full architecture needs to be documented as this will be needed both to successfully test the research results and to provide a production service. We present a comprehensive architecture that addresses actual use cases end-to-end, rather than simply an architecture of the services that are within the scope of our research.

1 Introduction

1.1 TAS³ Architecture at Glance

The TAS³ architecture provides the high level design of an infrastructure intended to provide the next generation of trust & security eco-systems that can (1) meet the requirements of complex and highly versatile business processes, (2) enable the dynamic user-centric management of policies and (3) ensure end-to-end secure transmission of personal information and user-controlled attributes between heterogeneous, context dependent and continuously changing systems.

The trusted architecture is built on three foundations: technical, policy and legal.

The technical architecture, introduced and described at a high level in this document, presents the different services that are needed in order to operate a trust network (or eco-system). Other work package deliverables provide more detailed designs of some of these services.

The technical architecture proposes a number of Policy Decision Points (PDPs) that are services capable of evaluating policies of various kinds and returning policy decisions to their callers - the Policy Enforcement Points (PEPs). The correct enforcement of user's policies engenders trust in a network. Many policies in a TAS³ trust network will be sticky policies, meaning that the policy and the data to which it pertains, are cryptographically bound together, thereby ensuring that the policy is always there to be correctly enforced. Various types of policy and PDP are envisaged, trust PDPs, privacy PDPs, authorisation PDPs, delegation PDPs etc. Details of these PDPs and the policies they support will be provided in more detail in other workpackage deliverables e.g. from WP4, WP5, and WP7.

The legal framework and set of model contracts will be further developed in WP6. They are being designed to contractually bind all the service providers into operating in a trustworthy manner, for example, so as to honour all the choices of users concerning the handling of their personal information. As many trust enabling factors as possible will be built into the technical infrastructure described in this deliverable, thereby automating the controls and freeing organisations from the worry and overhead of ensuring that they do the right thing. When it is not possible to engender trust through technical controls alone, then legal controls through our model contracts will be used as the controls of last resort.

This architecture document describes a service oriented trust network. All the conceptual entities that are needed to form a trust and privacy preserving secure network operate as service providers and service consumers, and they collaborate together to provide the security services to end users. These trust, privacy and security services are application independent and are designed to ensure that whatever application the user is using, the application and its data are as secure, trustworthy and privacy preserving as is possible, given the risk assessment and cost constraints of the trust network. (We accept that absolute security is both technically impossible and financially unaffordable.)

The trust and privacy enhancing services offered by TAS³ include:

- authorization services, whose purpose is to answer the question "is this subject authorised to access this resource in this way"
- authentication services, whose purpose is to identify a subject and validate that the communicating party is indeed the identified subject
- privacy preserving services whose purpose is to provide pseudonymous identities for users and minimise the cross linking of identities
- trust negotiation services whose purpose is to determine if the remote communicating party is trustworthy enough to start a dialogue
- secure business process management services whose purpose is to ensure that business processes operate securely, and can be dynamically modified securely
- delegation services, whose purpose is to delegate credentials from a delegator to a delegate
- discovery services, whose purpose is to inform clients where particular services can be found
- trusted registries, whose purpose is to keep a directory of all services in the trust network who are known to provide services conforming to the TAS³ specifications
- attribute authorities whose purpose is to assert that particular users have particular attributes
- identity management services, which are a combination of an authentication service and an attribute authority
- secure repository services, whose purpose is to store users' personal data securely and give users complete control over who should access their data and how they should handle it once they are given access to it
- trust and reputation services, whose purpose is to answer the question "how trustworthy is this actor (service provider or end user)"
- secure audit services whose purpose is to keep a tamper resistant record of transactions within the trust network so that legally admissible evidence can be obtained in the case of a dispute.
- on-line compliance testing services whose purpose is to ensure that all the services in a trust network comply with their published specifications and policies.

All of these services are usually needed regardless of the applications that might run in a TAS³ trust network. However, small centralized trust networks may be able to dispense with one or more of these trust and privacy enhancing services, e.g. discovery or delegation services, depending upon their requirements.

The TAS³ architecture is designed to be standards and protocol agnostic so that any protocol capable of implementing the message flows and service requirements of the conceptual service providers can potentially be used by any application. However, in order to ensure interworking between the prototypes being developed in this project, we have had to choose a subset of current state of

the art protocols. Deliverable D2.4 maps (some of) our services onto the latest state of the art application independent protocols as far as is currently possible. Further standardization effort which is needed in order to fully complete this mapping is documented in D2.4 and in other TAS³ deliverables.

1.2 Methodology

In presenting the architecture, we follow the FMC (Fundamental Modelling Concepts) [FMC03] methodology for presenting the high level static structure. For flow diagrams we use a mixture of UML [UML2] sequence diagrams and ad-hoc "white boards". The richness of the latter allow us to better convey relevant control flow and dataflow aspects simultaneously.

For more detailed descriptions we use UML [UML2] modelling, with occasional ad-hoc diagrams to clarify aspects that are not easily communicated using formalisms.

While we usually define, inline, the terminology we use, the authorative definitions are in [TAS3GLOS]. All architecture documents use this same Glossary and it will not be duplicated in the individual documents.

The stakeholders in context of TAS³ Architecture are

- Users accessing their own data
- Professionals working on the data of others
- Service Providers, TTP Operators, and Trust Guarantor (jointly Deployers)
- Security Officers
- Implementers
- TAS³ Members
- Policy Makers
- EC Framework Program 7.

The TAS³ mandate is to build secure, trustworthy, and user-centric technology ([TAS3DOW] section B.0 "Summary"), thus we have adopted a methodology where every composition and flow includes a User facet. Most of the flows are viewed from the User perspective and the business and regulatory aspects are filled in from this perspective. Given that gaining trust of the Users is fundamental to wide spread adoption, we have opted to emphasize security, transparency, privacy, and user control when trading off efficiency and simplicity.

This document has two goals: (1) Act as an authorative and prescriptive definition of the TAS³ architecture, and (2) communicate the architecture to the stakeholders, especially Deployers and Implementers. The latter goal is much in line with "Architect as Communicator" in Fig-1 of [FMC03].

1.3 Normative Claim

This document describes the final version of the TAS³ Architecture in a normative and prescriptive way. Any implementation or deployment claiming " TAS³ compliance" MUST abide by this document as well as [TAS3PROTO], and [TAS3COMPLIANCE]. A deployment usually has to satisfy additional requirements of the Trust Guarantor's Governance or Consortium Agreement and certification procedures, some of which concern the software implementation and others the organizational properties. Use of TAS³ Brand is governed by a separate TAS³ Brand Agreement.

This document uses the keywords (MUST, SHOULD, etc.) of [RFC2119]. All text is normative unless expressly identified as non-normative. Prose and specification have precedence over examples, which in absence of normative text, should be considered RECOMMENDATIONS. Examples as used in the documents are illustrative of the application of the relevant principles contained in the documents and are not statements of principles.

1.4 Review of Previous Work

TAS³ extends the State of the Art, as established by Identity Web Services Framework [IDWSF08], [HafnerBreu09], the Nessi Reference Architecture [NexofRA09], and Access-eGov Platform Architecture [AeGArch07]. [IDWSF08] includes a high level view, derived from documented requirements, and a low level implementable profile of various specifications backed up by interoperability and certification programs that verify interoperability in real life. [NexofRA09] only provides high level view and does not address identity issues (they even use term "federation" inaccurately, liable to cause confusion with Identity Federations) or interoperable protocol profiles - the definition of NEXOF Compliant Platform (NCP) is too vague and there are no interoperability or certification programs - [NexofRA09] fails to recognize clear prior art in [IDWSF08]. TAS³ extends the State of the Art by combining the web service, or SOA, framework with comprehensive authorization and trust management system, modelling domain, compliance validation (i.e. interoperability), and legal framework - in a whole that is concretely implementable. TAS³ addresses Long lifetime, Different Owners, and heterogenous IT environment concerns listed in [NexofRA09], Section 3.3. NexofRA discovery does not address discovery indexed by identity, though it does address discoverability by developers, which may be important for adoption.

[AeGArch07] architecture does not specify any concrete and interoperable implementation profile and its security details are vague. Never-the-less, they mention (but do not normatively reference) SAML SSO (no version), and WS-

Security (no specific version or profile). They do recognize need for registry and discovery function, but do not discuss the interesting parts. Overall it appeared that their main ambition is not in architecture. They overviewed existing art and picked SOA and applied it to their problem domain using existing concepts without details research in the architecture area.

They use WSMO (http://www.wsmo.org/) based WSMX (Web Services Execution Environment).

The Web Service Modeling Ontology (WSMO) aims at describing Web Services in a machine understandable format, and thus enabling the automatic discovery, selection and composition of Web Service. As a result, WSMO provides a semantic to allow multiple organisations to cooperate for the completion of a service. For example, the Accredetation of Prior Learning (APL) process [TAS3D91PilotUC] requires multiple organisations to be contacted to build the portfolio of a candidate. WSMO is divided in four core components; namely ontologies, web services, goals, and mediators. The ontology element provides a syntax to describe ontological entities (e.g. concept, relation, axiom), which can then be used to represent the semantic of a domain of discourse. In other words, the ontology provides a common conceptualisation of the domain used the other WSMO components. The web service element semantically defines every aspect relevant to web services, such as functionalities and interfaces. For example, the functionality of a web service is expressed in terms of its capabilities and of the pre- and post-conditions associated to them. The goal element specifies the users' objectives to be fulfilled by the execution of one or more web services. Finally, the mediator element establishes interoperability between mismatched resources. For example, it resolves mismatches in heterogeneous ontologies by finding mappings between their respective ontological entities.

1.5 Reader's Guide

This document conforms to the TAS³ project-wide glossary [TAS3GLOS].

If you are a nontechnical reader you may want to start from Annex C to get overall understanding of the user experience, then skim the main document and perhaps consulting Figs 2.1 may be useful. You should also consult [TAS3BIZ] which gives a good motivation for the work shown here. You may also find [TAS3WP] and web site www.tas3.eu helpful in understanding the overall TAS³ concept.

If you are a researcher, this document is the right place to start to see where your research may fit within the architecture.

If you are a software developer you will want to read this document, but you will also want to read carefully [TAS3PROTO], which details protocol versions and gives suggestions about available open source packages that implement these protocols.

If you are a deployer, you should skim this document, perhaps look at [TAS3PROTO], and then work through [TAS3COMPLIANCE] as you prepare for your TAS³ certification.

If you are a reviewer, you should read Section 2 and then any other sections or annexes that interest you.

2 TAS³ High Level Architecture

2.1 Overview

Basic security measures. Secure encryption, message digest, and digital signature algorithms are used through out where applicable. All Users and System Entities are authenticated to appropriate degree. For the latter this means PKI authentication, but for the former anything from passwords to hardware tokens is possible. The details of these algorithms are not repeated here, but are covered in [TAS3PROTO] and [TAS3COMPLIANCE].

The TAS³ Architecture is a reusable overarching design that can be instantiated any number of times. It specifies a Trust Network (TN) and the manner in which the players, including Users and Service Providers, interact in the Trust Network. The TN may be composed of several organizations, mainly Service Providers (SPs), each of which may constitute a subnetwork and may participate in several other Trust Networks. The architecture addresses interaction of the subnetworks with each other and the top level Trust Networks. We also foresee multiple Trust Networks coexisting and interacting to various degrees. An organization can simultaneously belong to multiple TNs as long as it can simultaneously satisfy the requirements of each network.

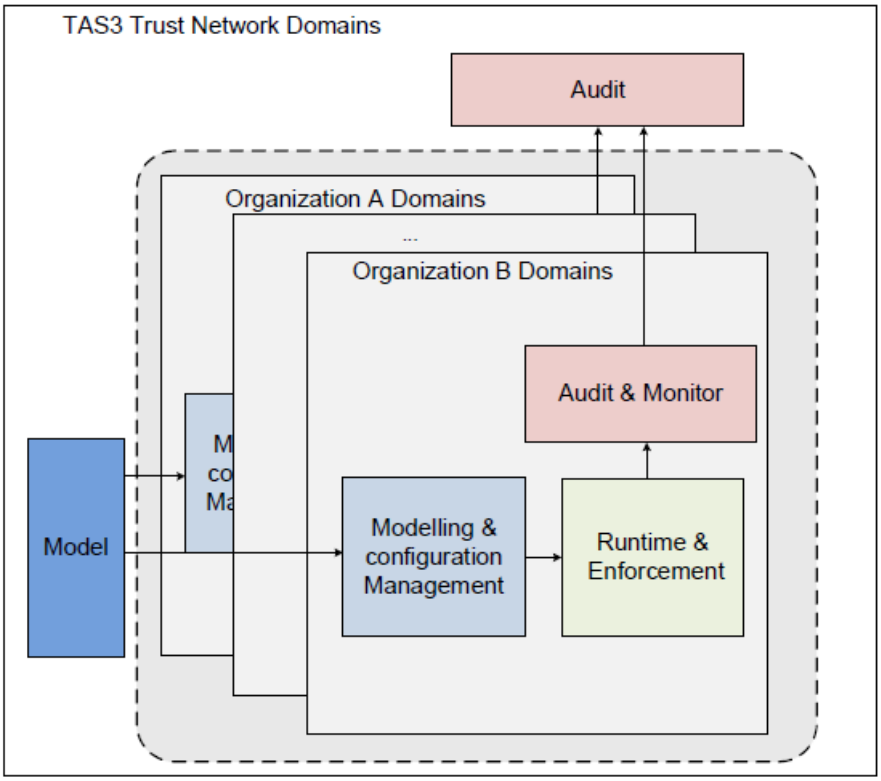


Figure 2.1: Using TAS³ top level model to start modelling of organizations that participate in Trust Network.

Each Trust Network works in the legal context defined by its Governance Agreement. This architecture specifies some functions that are strictly necessary for protocol flows to work, and other functions that are necessary to satisfy

nonfunctional properties like "secure" and "trustworthy". To impose on the players that the latter functions are implemented as well, we rely on legal obligation that stems from the Governance Agreement, as well as certification and audit programs, operated by the Trust Guarantor, to check that the legal obligations are met initially and on continued basis.

TAS³ **Trust Network Domain.** Consider Fig-2.1 where a Trust Network (TN), has chosen to adopt the overall TAS³ approach (which this and other documents specify). This means that at the "Summit" there is a Trust Guarantor (TG) who imposes on the TN the rules and model of operation. TG usually employs a Security Officer to maintain and enforce the model. The individual organizations may also have Security Officers responsible for their internal modelling and auditing.

Model. The Trust Network Domain configuration will be expressed using business process models, ontologies, and other models. The models are refined by each organization in their Modelling and Configuration Management. There will be several ontologies: architectural roles (e.g. Service Requester, Services Provider, Identity Provider), security ontology, privacy and data protection ontology and trust ontology. Payload services may define application specific ontologies, but they are not in scope of the TAS³ architecture. Ontologies in TAS³ are further discussed in [TAS3D22UPONTO]. Some mandatory policies emanating from EU will be modelled by the TAS³ project and incorporated to every TAS³ Compliant Trust Network Model (Req. D1.2-6.15-MinPolicy).

Audit and Oversight. The Trust Guarantor in its oversight role will operate compliance validation and audit functions. Each organization is expect to operate similar functions locally as Audit & Monitor. The audit trail stays principally within the organization, with Trust Guarantor only seeing summary records. There are some network wide reporting and auditing requirements that guarantee that other parties in the network, and especially users, have enough transparency to operation of each party. This helps to transparently understand that what has happened is legitimate, prevent fraud, and increase overall trust in the network - a key business goal of TAS³.

Runtime and Enforcement concerns delivering the useful payload services, with appropriate mechanisms to authenticate and identify Users and Systems, as well as authorize the operations. Most of technical realization of TAS³ happens in this area.

Cross Domain and Cross Context. TAS³ Architecture expressly enables operation of services across domains. This can mean several organizations in one Trust Network, or it could even mean interworking of several Trust Networks.

2.2 Basic Architectural Entities

In this section we drill down in the static component view of TAS³ architecture.

2.2.1 Major Components

Our architecture, see Fig-2.2 starts with User interacting with the Runtime & Enforcement area. Since TAS³ architecture is user centric, all action starts

directly or indirectly with the User. Even offline, user not-present, processes are seen to have been authorized by the User at some earlier time.

In the **Runtime** area, the User will interact with Payload services to obtain the tangible business benefits that motivated him to use the services in the first place. However, for the Payload to work in secure and trustworthy manner, services from Infrastructure are needed. For the system as a whole to remain secure and trusted, functions in the Audit and Monitor area are needed. They will receive their input through Audit Event Bus of the Runtime environment.

Front End Service. User's principal point of interaction with the system is a GUI, most commonly a Web GUI. This is a special kind of Service Provider that instead of speaking Web Services, e.g. SOAP, offers a user friendly interface. The Front End Services often call Web Services to perform all or parts of the functionality they provide. It is possible that the GUI is generated to match a Business Process Model.

Web Service. Machine accessible endpoint fromwhich data or action services can be obtained. Machine to-machine nature of Web Services is in contrast with the user-to-machine nature of the Front End Services.

The exact sequence of Web Services called will depend on a business process, whether expressly modelled or implicit to the design of the web services. A business process can encompass several Front Ends and the Web Services they call.

Business Process Engine is an orchestrating entity that controls how Front Ends and Service Providers, often Web Services, work together to achieve the objectives of the business process. It is depicted here as being a separate service, but "in process" realizations are equally likely. In such case the Business Process Engine would be inside the Front End Service, perhaps as linked in library. The role of the Business Process Engine is to serve payload business processes. There is a similar Trust Network Process Manager entity that, while technically similar, will exclusively execute business processes critical to the TN itself.

Dashboard is an important auditing and trust building feature of the TAS³ Architecture. It is a user interface, a Web GUI, that allows the User to understand and audit how the system as a whole uses his Personally Identifiable Information (PII). The Dashboard may also integrate a user interaction facility, PII Consent Service, for asking users consent or other input that is required for a business process to advance. A listing of the business processes in which the user has participated, or is participating currently is provided as well as a listing of Service Providers that hold data about the user or have handled his data. All these features provide transparency. (Reqs. D1.2-2.11-Transp, D1.2-3.3-Dash, D1.2-6.3-WhatHowWhyWho, and D1.2-12.15-Valid)

Identity Provider is the point where Users actually authenticate to the system. After authentication, the IdP issues a Single Sign-On (SSO) token so that the Front End Service can complete the login process. IdP has also an important role in providing Id Mapper bootstrap token for the User.

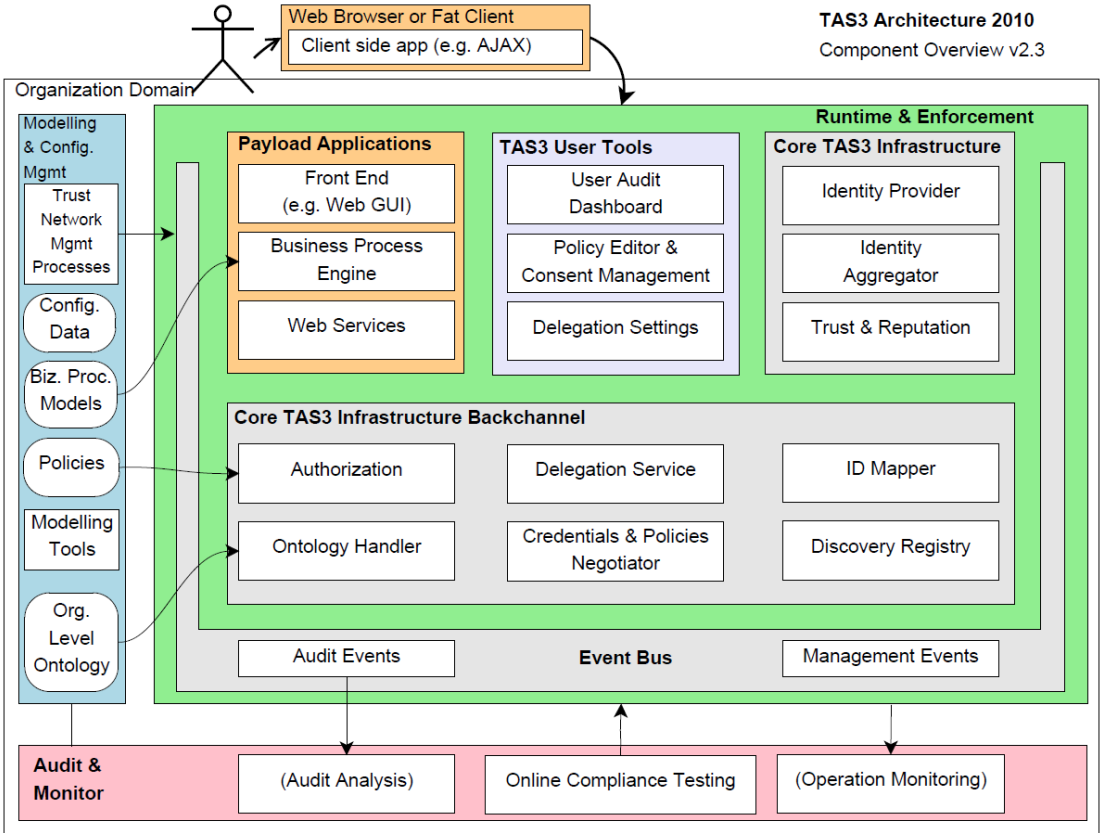


Figure 2.2: Major components of Organization Domain.

Authorization. This box actually represents an entire subcontinent of functionality. Authorization is pervasive in TAS³ architecture. This topic is treated in more detail in Section 2.2.3.

Delegation provides mechanisms for one User to allow another User to use FE or WS services on his behalf. Delegation also includes mechanisms for introducing users to one another, such as invites. In some cases User can be replaced in delegation by a juridical person. In delegation both the delegator and delegatee may be authenticated indirectly. A situation similar to delegation arises when User instructs a service to act on his behalf. In this case the delegatee is a system entity, usually a Service Provider, and is authenticated directly. The act-on-behalf delegation is handled by the ID Mapper component. (Req. D1.2-7.1-Deleg)

Trust Reputation encompasses a number of components that deal with gathering reputation data, usually via Audit Event Bus, and computing trust scorings that are then used in Authorization and Trust and Privacy Negotiator components. The trust and reputation system is also used to detect certain classes of fraud (Req. D1.2-7.21-Safe).The architecture and design of this subsystem is further elaborated in WP5 deliverables.

Trust Network Process Manager. There are many maintenance processes that a trust network must realize in order to work dynamically and react to threats rapidly. These include intake process for users (Req. D1.2-6.1-IntakePers), intake and certification process for organizations (Req. D1.2-6.2-

IntakeOrg), and user's access to his own data and audit trail (Req. D1.2-6.8-UserAccess). The application specific business processes belong to Business Process Engine, above.

Id Mapper (IM) is used to translate User's IM token (Id Mapper bootstrap token) to a token usable for Web Service that is about to be called. Such translation is necessary as the user is known by different pseudonym at different services. This is used to express act-on-behalf relationships where Service Provider (delegatee) wields a token provided by Id Mapper (or in some cases by IdP). (Req. D1.2-2.3- BMs)

Registry Server contains knowledge about which end point serves which type of service for any given User. Typically Registry is queried as a preparatory step of web service call proper, but it could be queried in advance. (Req. D1.2-2.3-BMs)

Linking Service (aka Identity Aggregation) provides a facility for a user to indicate how he wishes his attributes to be aggregated. This links together the user's accounts at different IdPs, allowing the user to aggregate attributes from multiple IdPs in a single session with a service provider.

Obligations Service (not depicted) provides a way to process many commonly occurring obligations such as data retention limit. Obligation handlers register with the obligations service. The service uses this information to advertise its capabilities in satisfying obligations. This leads to trust and privacy negotiation.

Trust and Privacy Negotiator. This is the server side of the negotiation. Every Service Requester, such as Front End Service, must implement Trust and Privacy Negotiator Client Agent (not shown in the figure). The Client Agent can be implemented as a web service and the Service Requester merely performs a web service call to the agent, which then engages in trust and privacy negotiation protocol with the web service provider's Trustand Privacy Negotiator. Trust and Privacy Negotiator functions in many ways similar to the registry, but instead of returning all end points, only some are returned based on trust scoring. The Trust and Privacy Negotiator relies on the user's Linking Service in order to access all the distributed attributes of the user.

Modelling and Configuration Management is connected to the TN level modelling. It also contains local ontologies, such as trust and privacy ontologies, and local Models and Configurations. All of these may be edited using Modelling Tools. From Models and Ontologies, configuration items can be generated and pushed to the Runtime using Management Event Bus, as governed by the Trust Network Process Manager.

An essential element of this architecture are community-managed ontologies, which allow for unambiguous, but flexible, meaning agreement at all times. We can envisage several roles for these ontologies. It first provides a machine-understandable documentation of the architecture as well as a formal vehicle to exchange explicit semantic agreements (i.e. commitments) between partners and, eventually, systems. Thus, these commitments will enable the enforcement of (organisational and/or legal) policies within the TAS³ architecture. For example in Role-Based Access Control (RBAC), the role of a subject in one organisation may be different to that in another organisation where access is being granted.

The ontology will allow the roles to be mapped to each other so as to be able to enforce authorization based on the privileges assigned to that role.

Secondly, the ontologies will assure that relevant parts of the system commit to the same interpretation of possibly ambiguous elements to allow for meaning alignment, certification and early conflict discovery. These ontologies will enable improved understanding; common methods of expressing terms enabling people and organisations to better trust each other in these application environments. TAS³ will integrate these architecture elements into a fully embedded trust framework to automate business processes managing personal information, which will result in considerable societal benefits. The Semantic Interoperability Engine (Fig-3.15) will facilitate the interoperability across different contexts (e.g. across different organizations). Ontologies are further discussed in [TAS3D22UPONTO].

2.2.2 Enforcement Points on Web Service Call Path

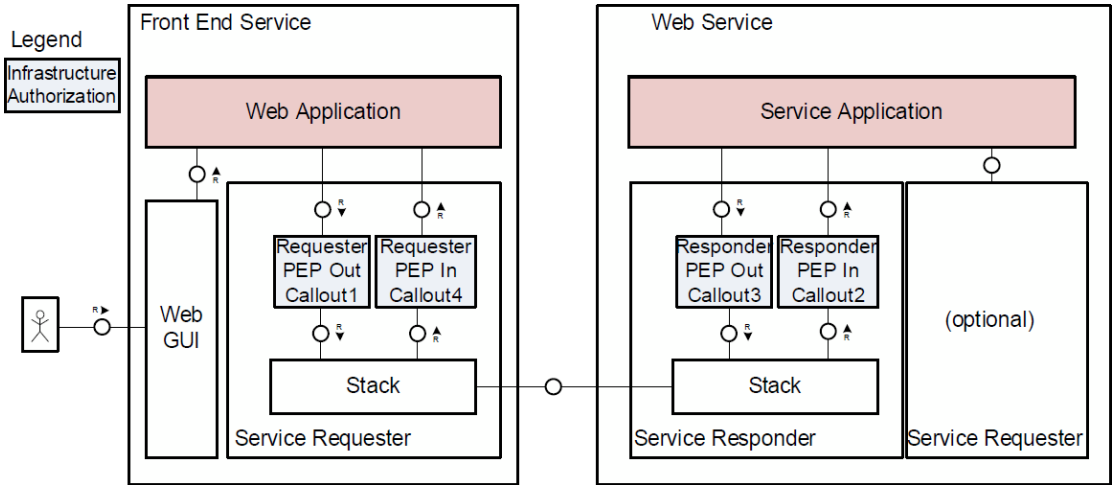


Figure 2.3: Front End calls Web Service, passing through 4 enforcement points (callouts, per Fig-2.2 of D7.1).

Considering Fig-2.3, a Front End (FE) is composed of a Web GUI, a Web Application (the payload of the front end), and a Service Requester module which is used to call Web Services. The counter part of the Service Requester is the Service Responder module of the Web Service.

Service Requester is a software module that encapsulates the mechanics of performing a Web Service call. An implementation of the Service Requester module will be provided as a deliverable of the TAS³ Project. However, it is possible to implement this independently as long as all requirements prescribed here are maintained.

Service Responder is a software module that encapsulates the mechanics of accepting a Web Service call and responding to it. An implementation of the Service Responder module will be provided as a deliverable of the TAS³ Project. However, it is possible to implement this independently as long as all requirements prescribed here are maintained.

PEPOut-Rq. Service Requester Outbound Policy Enforcement Point (PEP). This PEP is used to check whether data can be submitted to the Web Service, or whether the call can be made at all. The PEP will contact organization's Master PDP to obtain a policy decision.

PEPIn-Rs. Service Responder Inbound PEP. This PEP is used to check whether data or call can be accepted by the Web Service. It also records what obligations and policies does the Service Requester pledge to honour. These will be checked later by PEPOut-Rs.

PEPOut-Rs. Service Responder Outbound PEP. This PEP is used to filter the data on responder side and to perform any responder obligations attached to the data. In particular, the pledges recorded by PEPIn-Rs are checked against obligations and sticky policies attached to the data and if found unsatisfiable either data is filtered out or operation aborted. If no data can be returned, an error response will still be returned.

PEPIn-Rq. Service Requester Inbound PEP. This PEP is used to extract and perform or record for later performance any obligations attached to the response.

Recursive Call

As shown in Fig-2.4, it is possible to chain web services calls, such that the application layer of upstream server may invoke as client a down stream service. There is no difference whether the Service Requester module resides in right hand side of a Front End or a Web Service, turned into Web Services Client (WSC). This pattern can be repeated in any tree topology to any depth of call - however in practical implementation the call depth MAY be limited to some number to avoid infinite recursion.

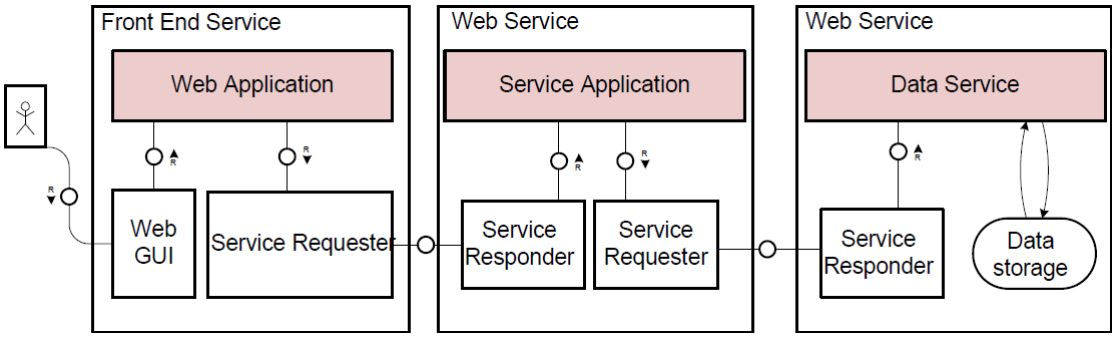


Figure 2.4: Recursive Web Service calls.

2.2.3 Authorization Infrastructure

Authorization is everywhere in TAS³ Architecture. It often gets rolled up in small, but very meaningful symbol in the architecture. This is why we call authorization an infrastructure unto itself. It is described more fully in [TAS3D71IdMAnAz]. This section addresses Reqs. D1.2-2.19-AzCredi, D1.2-2.20-Az, D1.2-4.5-ComplyPolicy, D1.2-4.6-BrkGlass, D1.2-6.4-Min, D1.2-7.6-Az.

Fig-2.5 depicts some of the components involved in the authorization infrastructure. By far the most common case is that some payload service, such

as a Front End orWeb Service, needs to get an authorization decision and initiates the subflow.

Policy Enforcement Point (PEP). This is a software module usually built into the payload service. There are four fundamental types of PEP, as shown in Fig-2.3: in and out variants on Service Requester and Service Responder sides.

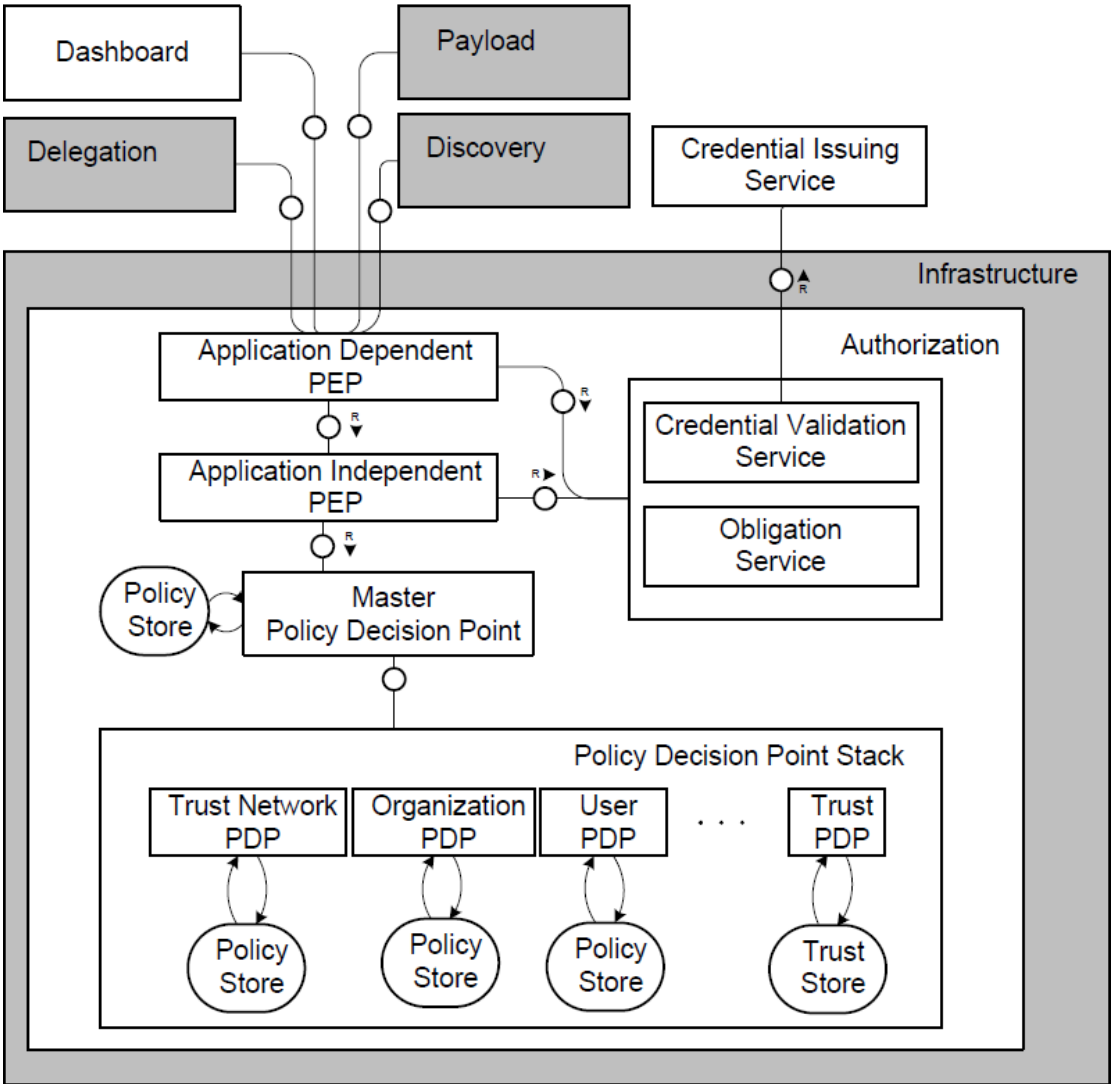


Figure 2.5: Authorization Infrastructure.

Master Policy Decision Point (Master PDP). The PEP calls Master PDP to obtain the authorization decision. Typically each organization will run a Master PDP (though other arrangements are possible). All logic of the authorization decision is masked behind the Master PDP. Thus the exact implementation details of Policy Decision Point Stack are irrelevant for the PEPs. The Master PDP handles coordination and routing of requests to the PDPs in the stack and aggregates the authorization decisions received from the PDP. In a way it can be viewed as a PDP proxy.

A BTG PDP wrapper (not shown) is responsible for arranging Break-the-Glass Authorization, see Section 3.5 and [TAS3D71IdMAnAz].

Trust Network PDP processes the policies that are coordinated at the Trust Network level, including the Legal Policies.. It can be implemented as a central Trust Network-wide service, or it can be distributed so that there is an instance of a Trust Network PDP at each SP, but the policies are centrally coordinated and pushed to the instances, perhaps using the Trust Network Process Manager.

Organization PDP processes the policies that an organization maintains. These policies may be over and above the Trust Network-wide policies, since every organisation has to abide by the rules of the trust network and the law. The distinction from Trust Network PDP is maintained because the authority for deciding the policies is different.

User PDP function may implement User specific policies, i.e. policies set by the User. This could also involve evaluation of Sticky Policies. In practise, the User PDP may be implemented inside the Master PDP process.

Trust PDP is an interface to the Trust and Reputation Management subsystem which allows the Master PDP to query whether a contemplated action is acceptable from Trust and Reputation perspective. Such query has the advantage that the Trust and Reputation system does not need to disclose to the Master PDP the exact parameters that lead to this decision. The deliverables of WP5 elaborates on the structure and design of Trust PDP and Trust and Reputation System at large.

Credential Validation Service (CVS) is a subsystem that helps PEP to establish the validity of the credentials and attributes it is about to pass to the Master PDP. Typically these are received from front channel interaction or from an earlier web service call. The validation involves checking that they are properly signed and that trust to the signing authority exists. Some namespace and syntax checks may be performed as well. The CVS may call on other components of the architecture to perform its functions.

Policy Information Point (PIP) is used to fetch additional attributes that may be needed for policy evaluation. The PIP may call, in a recursive manner, on other components of the architecture to perform its functions. Special care needs to be taken in preventing infinite recursion and to ensure that the policies in the recursive levels allow the information to be returned for purpose of policy evaluation. The PIP may be called either from the PEP or from the Master PDP. The exact choice is a question of optimization. The set of attributes needed for policy evaluation is determined by the SP, is shown to the user, and the user then chooses which of his attributes he wishes to submit in order to fulfil the SP's requirements. If further attributes are needed later on in a business process, the SP can subsequently reveal its requirements to the user, allowing him to choose some more.

2.3 Major Flows: Front Channel and Back Channel

Implementable Flows. The flows we present are designed to be implementable with existing state-of-the-art protocols and software stacks. In particular standards based approaches are used for authentication, delegation, token passing, identity mapping, service discovery, authorization, and web services calls. Despite this, the present high level architecture is designed to be standards

agnostic so that any protocol capable of implementing the flows and satisfying the requirements can potentially be used. See [TAS3PROTO] for details.

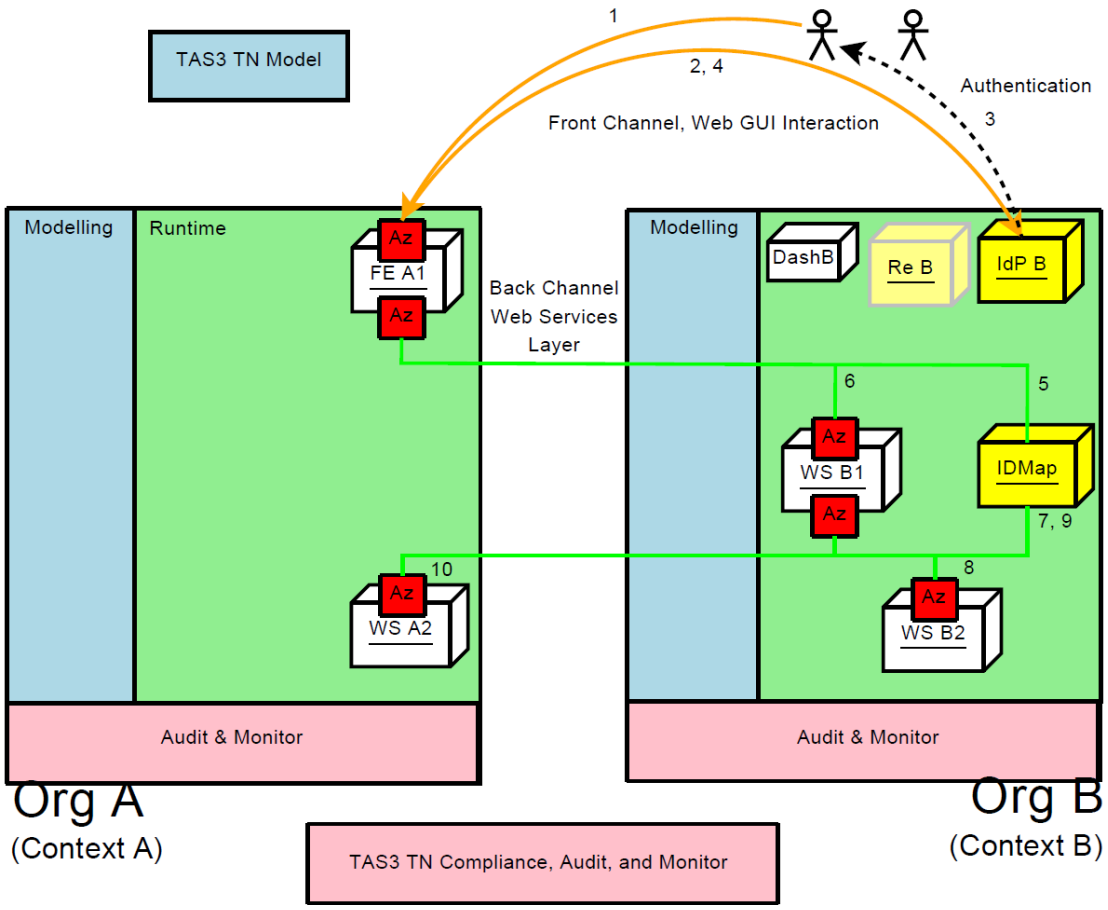


Figure 2.6: Front Channel and Back Channel Flows (the numbering indicates typical sequence of events).

From Fig-2.6 we can identify certain important principles (the authorization process is depicted in summary form as box "Az" to reduce clutter, see Section 2.5 for full description):

a. There can be any number of organizations in the Trust Network and each of these organizations may run a number of web sites (labelled as FE - Front End in the figure),Web Services (WS), and infrastructure services (sometimes called Trusted Third Parties).

b. Some architectural roles, like Identity Provider (IdP) can usefully be operated by several organizations in a Trust Network. The important point is that all the components are part of the model of the Trust Network and subject to its oversight.

c. Users will use their "home" IdP (e.g. IdP provided by their employer or educational institution) for Single Sign-On (SSO), but this does not prevent them from using web sites (labelled as FE – Front End in the figure, this is often called "front channel usage" or "user present scenario") of the other organizations (Req. 3.1 from D1.4), subject to access control decisions, of course.

d. The usage of a web site often triggers Web Services calls on the back channel. Finding out exactly which servers to contact and what credentials to use is handled by User's Discovery and ID Mapper services ("IDMap" in the Fig-2.6) (Req. 8.1 from D1.4). Usually the Discovery Service is rather tightly coupled to the IdP.

e. It is feasible and common that Web Services can be called across organizational boundaries. Discovery and trust negotiation within the model set by the Trust Network will enable this to be possible.

f. When auditable events happen, in addition to local logging, a summary of the data is sent to the Audit Event Bus. Subscribed to the audit summaries are: (i) User's Dashboard service so that the User can always see what happened and is in control; and (ii) the organizational and Trust Network audit layers. See blue arrows in Fig-2.7.

g. Although all organizations can potentially have all components, the fact that cross organization web site usage and service calls are explicitly provided for, makes it possible for an organization to outsource some, or all, of these services. Or the other way around, some organization may specialize in only providing the infrastructure services. This approach is often desirable to manage conflicts of interest.

This is a very flexible architecture and allows the responsibility for provision of services and infrastructure to be sliced and diced in many ways, according to business needs rather than technical limitations.

2.4 Overview of Data Models

2.4.1 Federation Relations for Core Security Architecture

> N.B. On first reading it may be advisable to skip this section as understanding of flows shown in Fig-3.4 will be useful.

One of the fundamental principles of the Core Security Architecture is use of federations, which may support persistent or transient identifiers. When correctly used, these types of identifiers allow privacy to be preserved by not leaking any correlation handles. This section addresses Reqs. D1.2-2.14-Priv, D1.2-7.8-NoColl, and D1.2-7.16-Nym.

In order to implement persistent and pseudonymous federations, the IdP and IM have to keep state. In general, the federation table for an IdP that supports persistent pseudonymous identifiers will hold mappings as follows:

```
User at IdP1 --> [ encrypted pseudonym of user at SPA,
                   encrypted pseudonym of user at SPB,
                   ...
                   encrypted pseudonym of user at SPN ]
```

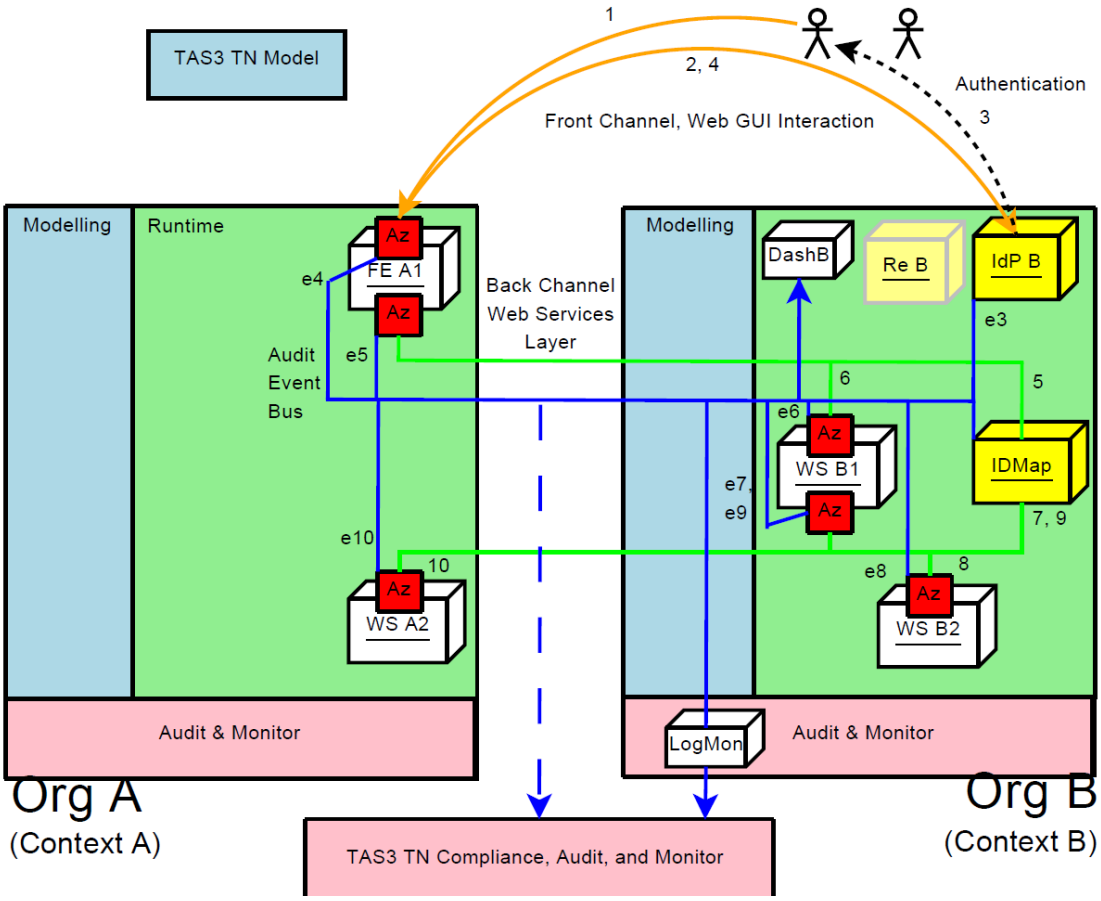


Figure 2.7: Audit Event Bus (the numbering indicates typical sequence of events, the e-numbers indicate audit events)

The federation table for IM needs similar mappings

```
User's pseudonym at IM --> [ encrypted pseudonym of user at SPA,
                             encrypted pseudonym of user at SPB,
                             ...
                             encrypted pseudonym of user at SPN ]
```

The IdP and IM may include attribute data in the tokens they emit. This attribute data can be kept in any suitable data structure, usually indexed by user and sometimes by SP, or both.

The IMneeds additional data structure to determine what services are available to a User. In its simplest form this would consist of

User's pseudonym	Service Type	SP EntityID
789IM	Role Author.	C.example.com
789IM	HR Authority	B.example.com
579IM	Role Author.	C.example.com
579IM	HR Authority	B.example.com

but other more general realizations can include data needed for Trust and Privacy Negotiation phase of Discovery. These will be explored in the Trust and Privacy Negotiation documentation.

An IdP may have a limited form of this table to cover the necessity of emitting IM bootstrap token during SSO.

All parties - IdP, IM, and SP (FE or WS) - need to maintain some metadata about each other. Such metadata may include SOAP endpoints, protocol profiles and bindings to use, etc. These will generally be specified in protocol specific documents as adopted in [TAS3PROTO], but for general idea the reader may want to see [SAML2meta].

There is also the requirement for a user to be able to aggregate his attributes together in order to gain access to web services. This requires an attribute linking service, which is fully described in [TAS3D71IdMAnAz].

2.4.2 Personal Data and Applications

A SP can use whatever data model it desires (TAS³ Architecture is not prescriptive in this regard) in storing the data about the Users as long as itmeets security and privacy guarantees detailed in [TAS3COMPLIANCE]. The persistent pseudonym of the User suggests an obvious database key, but other arrangements are possible.

TAS³ Architecture foresees aggregation of data from multiple sources with its support for policy aggregation. One common realization of this approach is to consider a document as a collection of external data streams, please see [TAS3D81RepoSW]. This approach will be supported by some of the TAS³ software deliverables (e.g. output of WP8).

2.4.3 Using Sticky Policies to Protect Data

Sticky policies can be attached to most data items and are especially foreseen to protect personal data and control its dissemination. The purpose for which the data was collected is expressed in the sticky policy. This section addresses Reqs. D1.2-2.21-DataProtLaw, D1.2-6.5-Purpose, and D1.2-4.1-EnfUCPol. Data origin and collection method can also be indicated using sticky policies (Req. D1.2-6.8-UserAccess).

Sticky policies are evaluated as part of the authorization process. In an untrusted network they should ideally be bound to the data they protect by encryption and signing that would prevent disclosure of the data unless the policy evaluates to permit. However, this is a difficult research problem to address, and untrusted networks are outside the scope of TAS³. In a TAS³ trust network the SPs are deemed to be trustworthy to the extent that they will obey sticky policies when they receive them. Therefore policies are bound to the data they protect by digital signing, but are not encrypted. If an SP receives data which the sticky policy says it should not have, then its inbound PEP will refuse to accept the data.

2.4.4 Using Encryption to Protect Data

All protocol flows use encryption. Usually this will be in form of connection level encryption, but in certain cases application layer public key encryption will be used to protect tokens or attribute data while it is in transit through an intermediary (e.g. IM token when passing through FE).

2.5 Authorization Process

This section partially addresses Req. D1.2-6.12-Sec.

Fig-2.8 depicts refined structure of the Authorization Process.

1. Central notion is that theWeb Service PEP ("=" above theWS1 in the figure) calls aMaster PDP, which then gathers the authorization from whatever sources it can.

2. Some of the data used for the decision may have come from the Web Service itself (it may have been inline in the Request, or the Web Service may know it otherwise), but if additional data is needed, the Master PDP will contact Policy Information Points (PIPs) as appropriate. (Processing of PIP request itself is an instance of Enforcement and Authorization Process, thus giving all of this rather recursive flavour.)

3. Trust and/or Reputation may be a factor in the authorization decision. This is handled by modelling the Trust and Reputation Provider (labelled as just "Trust" in the figure) as just another PDP that Master PDP calls. The feedback and inputs to the Reputation computation are not shown here.

4. Business-process-management systems need to enforce history-based authorization constraints such as separation of duty (SoD) or binding of duty (BoD). These constraints are enforced by a component of the secure BPMS (Section 4.5), while the part of authorization for tasks in business processes that does not depend on history information is delegated to the Master PDP.

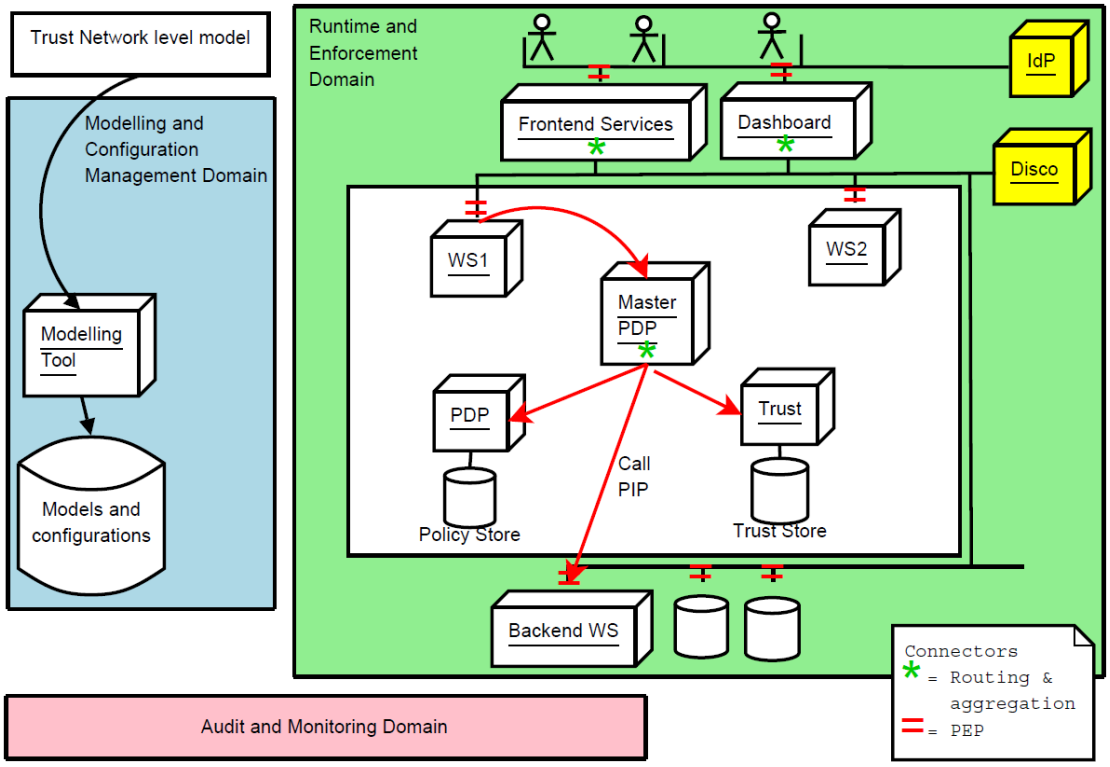


Figure 2.8: Authorization Process

5. Given that sticky policies may potentially be written in different policy languages, the Master PDP will detect the language and call appropriate PDP to have the policy interpreted.

2.6 Enforcement Process

This section partially addresses Req. D1.2-6.12-Sec.

When a Web Services call is made, there are several control points in the flow, as shown in Fig-2.10.

1. Request is first controlled by a Requester, i.e. on Client side, for being an acceptable request. For example, if the request is about to submit data to the Service Provider, there may be several policies about what can be submitted.

2. The controls can have multiple facets, i.e. the application programmer may have programmed in some implicit policies, the organization that operates the application may have some policies of its own, the Trust Network is certain to have policies, and finally the User himself may have set up some policies (which may involve attaching sticky policies to the data). Conceptually these are addressed by a PEP contactingMaster PDP which may contact stake holder specific PDPs. If different stake holder policies result in a conflict, the Master PDP implements a Conflict Resolution Policy to arrive at a decision. An alternative approach is to use Identity Governance Framework [IGF] CARML declaration to set up the PEP, or some part of it.

3. After request has been authorized to send, the Service Provider will examine if the request is acceptable using a similar stack of PEPs. Examination on Service Provider side is the "traditional" enforcement point that most people think about. It filters out inappropriate data requests as well as illicit writes.

4. When preparing to ship response, the Service Provider uses a PEP and Master PDP to further filter the response. Although the request side PEP should have made sure that only legitimate requests can ever

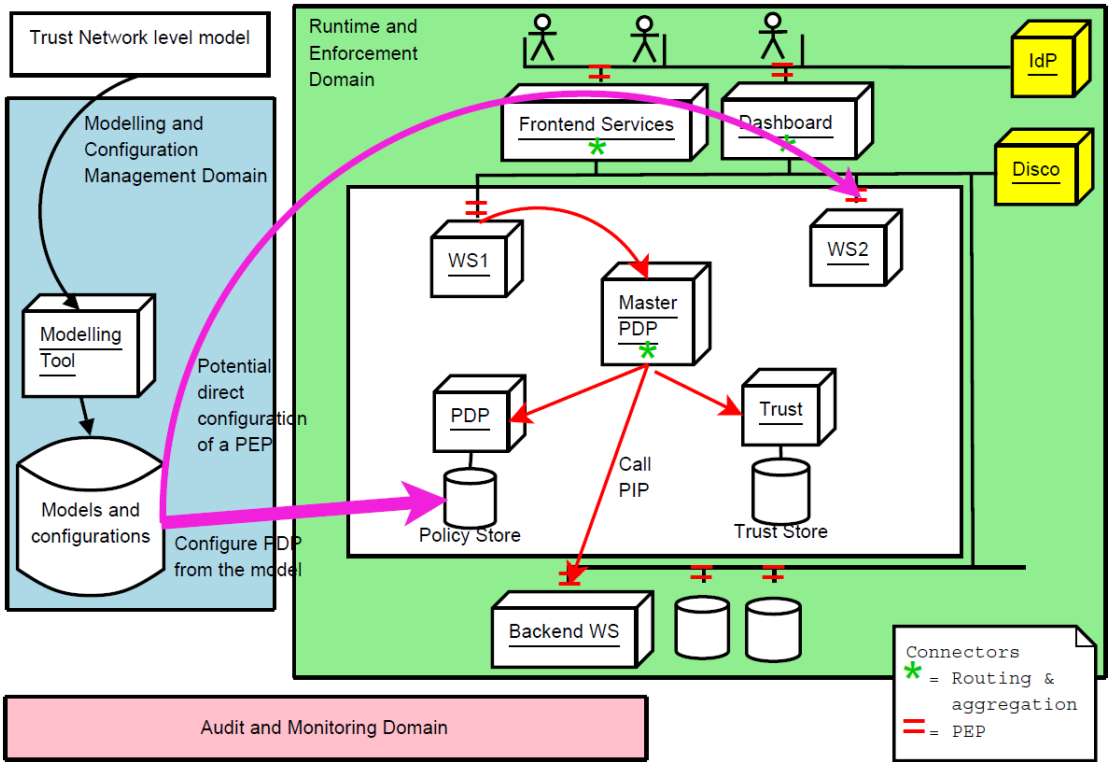


Figure 2.9: Using model to configure Authorization Process

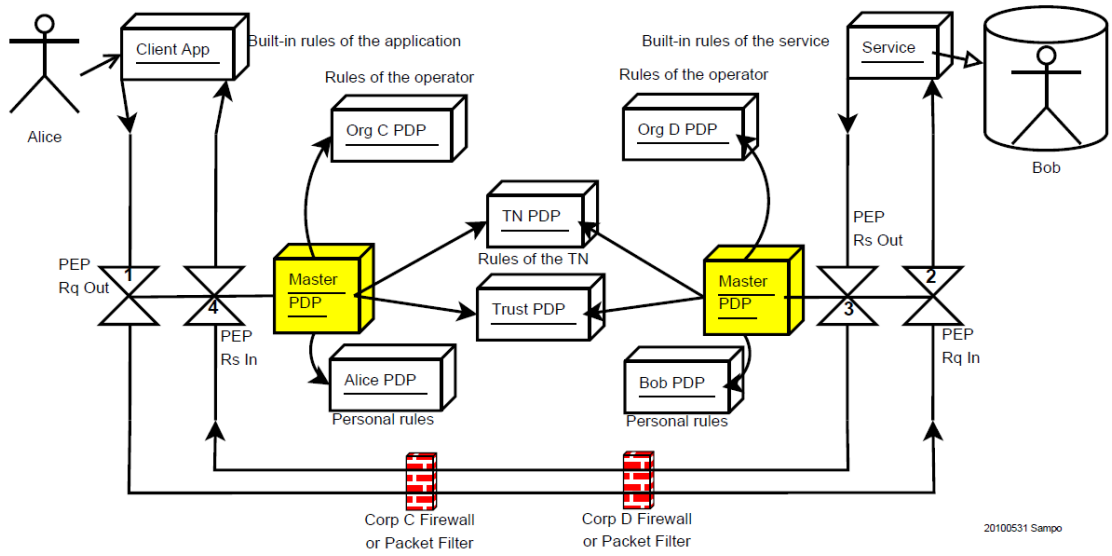


Figure 2.10: Arrangement of enforcement points in web service call flow (numbered callouts, per Fig-2.2 of D7.1).

get processed at the Service level, the returned results may still need some scrutiny, or this facility can be used to attach obligations and sticky policies to the returned data.

5. When Client receives the response, it examines it with a PEP and Master PDP. Such examination may be necessary to understand if there were sticky policies attached, or to perform obligations. Given the rules under which the Service Provider released the data, it may be that Client finds that it can not use the data for the intended purpose and therefore has to reject the request.

6. Not depicted, but logically part of the Client Request sending side are also
   a. discovery
   b. trust negotiation and establishment
   c. signing of request
7. Not depicted, but logically part of the Service Provider Request processing are also
   a. trust negotiation and establishment
   b. validation of message structure
   c. signature validation
8. Not depicted, but logically part of the Service Provider Response sending side are also
   a. signing of response
9. Not depicted, but logically part of the Client Response reception side are also
   a. validation of message structure
   b. validation of correlation
   c. signature validation
   d. processing obligations

2.7 Configuration Process

TAS³ is pervasively model driven. Fig-2.11 shows how a business process model can drive auditing processes, or even influence the Dashboard user interface so that Users can visualize the processes.

Fig-2.9, shows how models are used to configure policies for the PDPs. It also shows an alternate approach where PEP itself can be directly configured, e.g. using Identity Governance Framework [IGF] CARML and/or AAPML.

From the model the Trust Guarantor is able to derive

- Basic trust configuration, i.e. who belongs to the network
- a white list of members
- metadata to configure trust in the members
- Configurations to be pushed to operational elements of the network so that they will consistently enforce the process and trust model and the security model of the Trust Network.
- Operations Monitoring setup, e.g. if alerts are coming from some node, what Networks Operations Centre (NOC) process should they enter, where should they be disseminated, who should see them, and who is responsible for response
- On-line compliance testing configuration. This will drive a robot, spider if you like, that will comb through the Trust Network on a regular basis to

verify that each service is in compliance with the policies that it publicly manifests.

The Organizations A and B participate in the Trust Network. They also model their business processes, extending and refining the global model. They, too, will benefit from ability to automatically configure and monitor the components of their infrastructure.

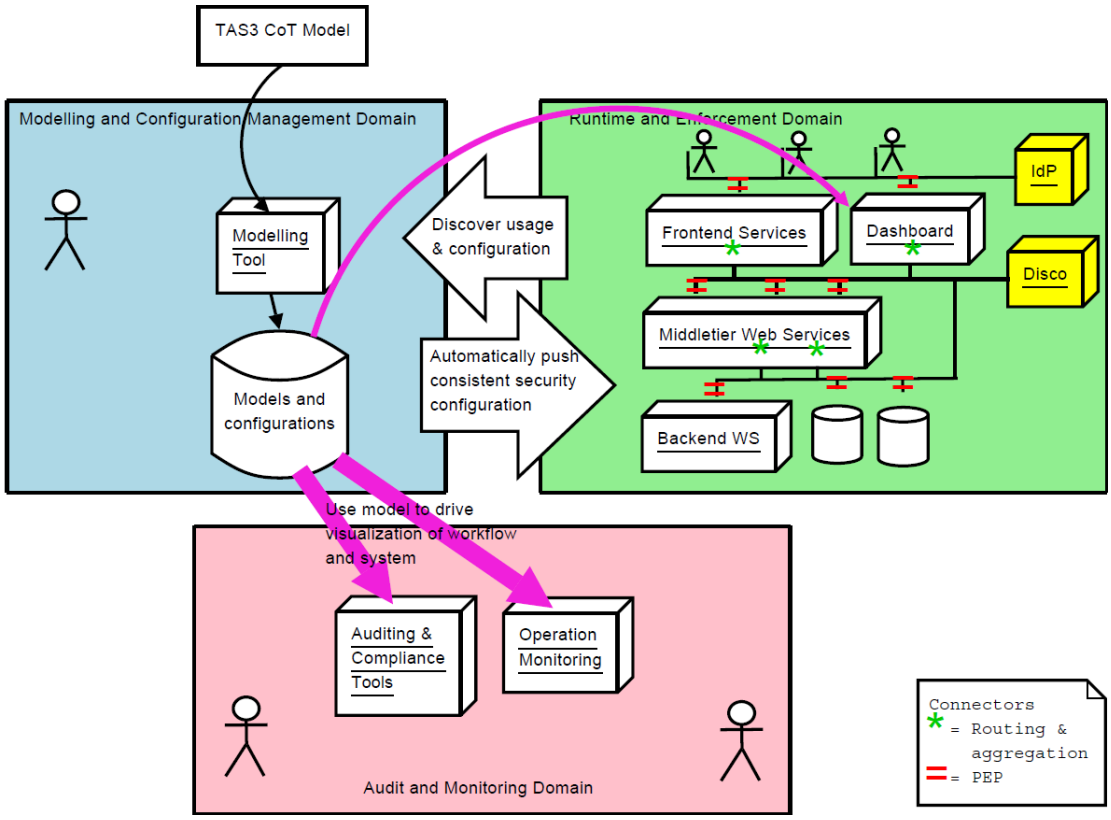


Figure 2.11: Pushing configurations from model.

2.8 Audit

There will not be any complete central audit log. The only audit data released routinely out of an organization or Service Provider are references to audit events and anonymised summary data. These summary records are stored in the trust network operators summary audit file. If an audit needs to drill into the distributed audit trail, the authorized auditor or the data subject will be given access, upon escalation, to fetch or view the local audit trails and ability to correlate the events to form a "big picture". Without such authorization correlation will not be possible. This principle applies to the User's Dashboard as well.

The audit domain is essential to maintain the validity of the trust fabric in the infrastructure. The domain will receive data on authorisation decision as illustrated in Fig-2.13. This enables the domain to become a central point for monitoring of authorisation processes in individual TAS³ instances.

The services in the auditing and monitoring domain will receive other forms of data linked to trust from the TAS³ infrastructure. This data will also include information on service invocations and workflow execution. The data from the results of these events will be stored in two main sets of services in the auditing and monitoring domain, there are auditing and compliance tools and operation monitoring tools.

It is important to note that these two sets of information will be handled quite separately. The operation monitoring tools will be operated by the applications code and will be application specific, whereas the auditing and monitoring will be operated by the TAS³ security layer and will be application independent.

The data collected from the monitoring in the audits can be then used by elements in the infrastructure such as the Dashboard. This will enable users to look at both how their data has been used in the infrastructure and also if any services have failed in this execution. In cases of failure or rogue behaviour the negative feedback from this can be fed to the Trust and Reputation service.

It is possible to store audit events referring to a particular business-process instance in the BPMS and present them to end users visually using the graphical representation of the process created in the modelling phase.

Some Audit Principles:

- Nobody should be able to tamper with the audit trail without detection. This includes insertion or removal of audit records, altering of audit records and deletion of entire audit files.
- Nobody should be able to put together the entire audit trail without proper authorization
- When answering a user audit request, the initial answer may have coarse granularity, such as organizations that have accessed. Only upon more thorough, authorized, investigation more detail, such as employees that have accessed would be revealed.

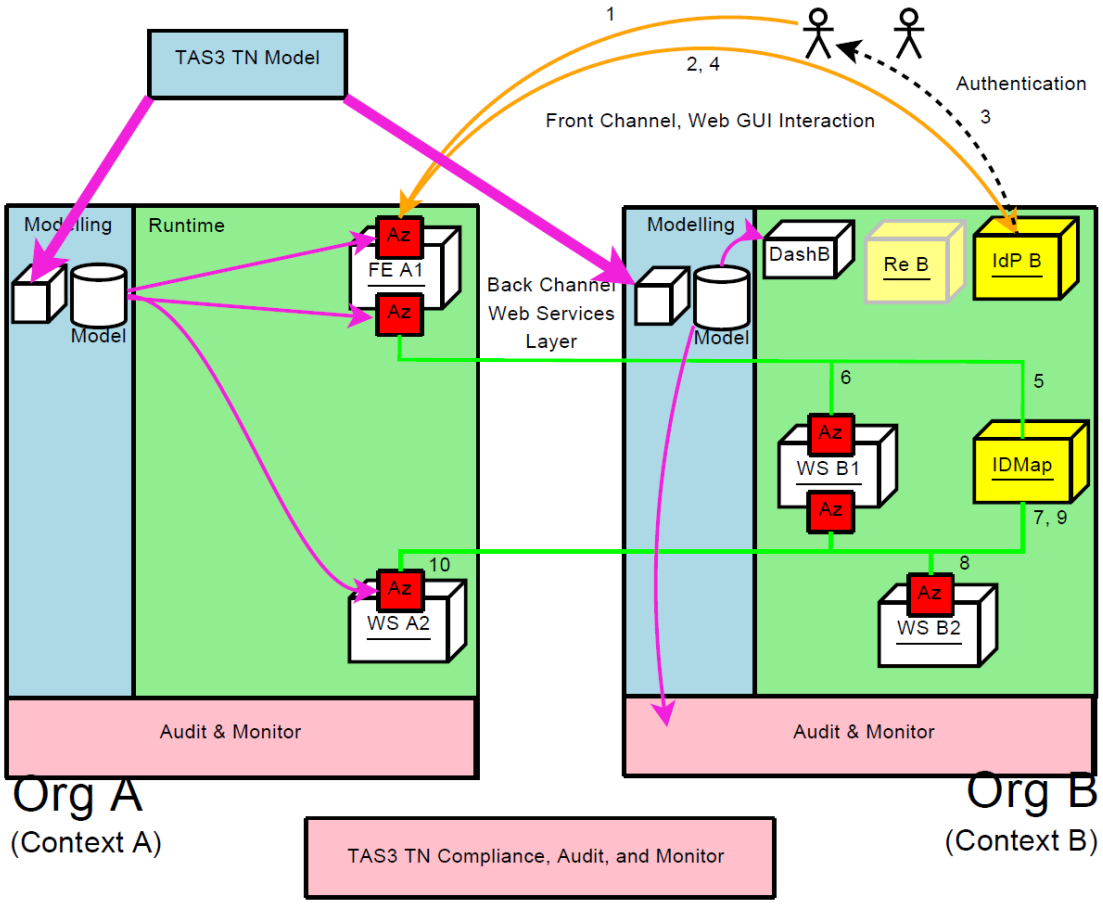


Figure 2.12: Configuration from Model (the numbering indicates typical sequence of events)

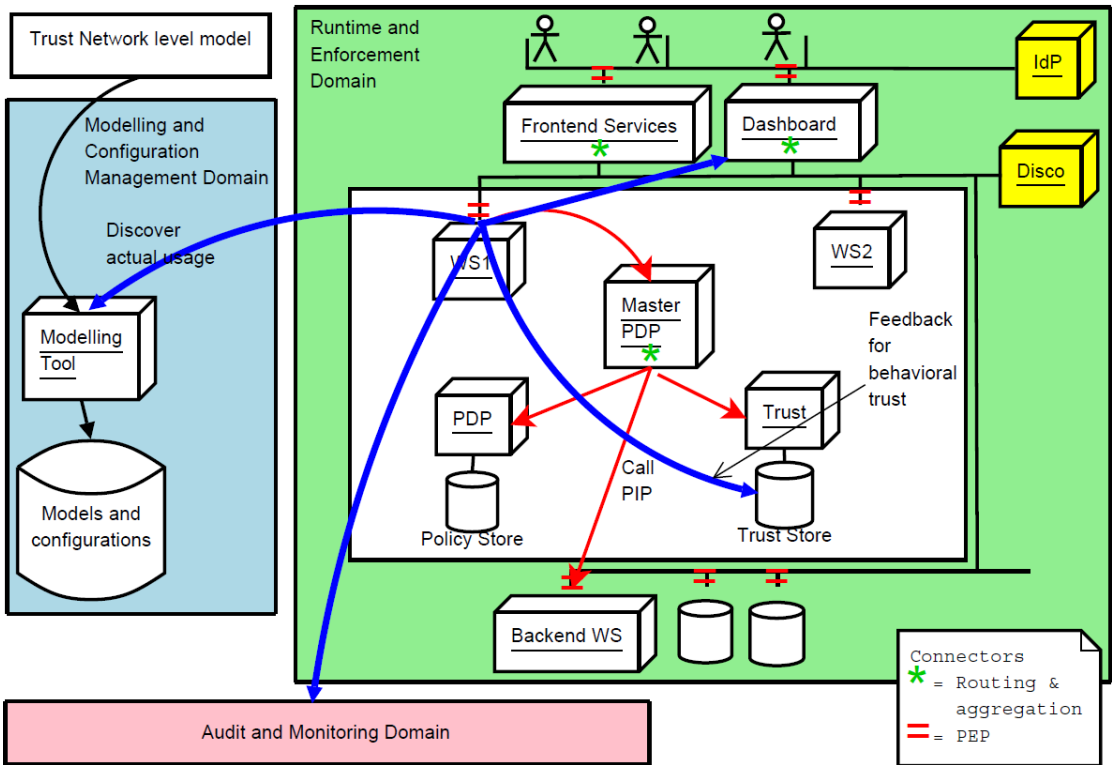


Figure 2.13: Auditing an authorization decision.

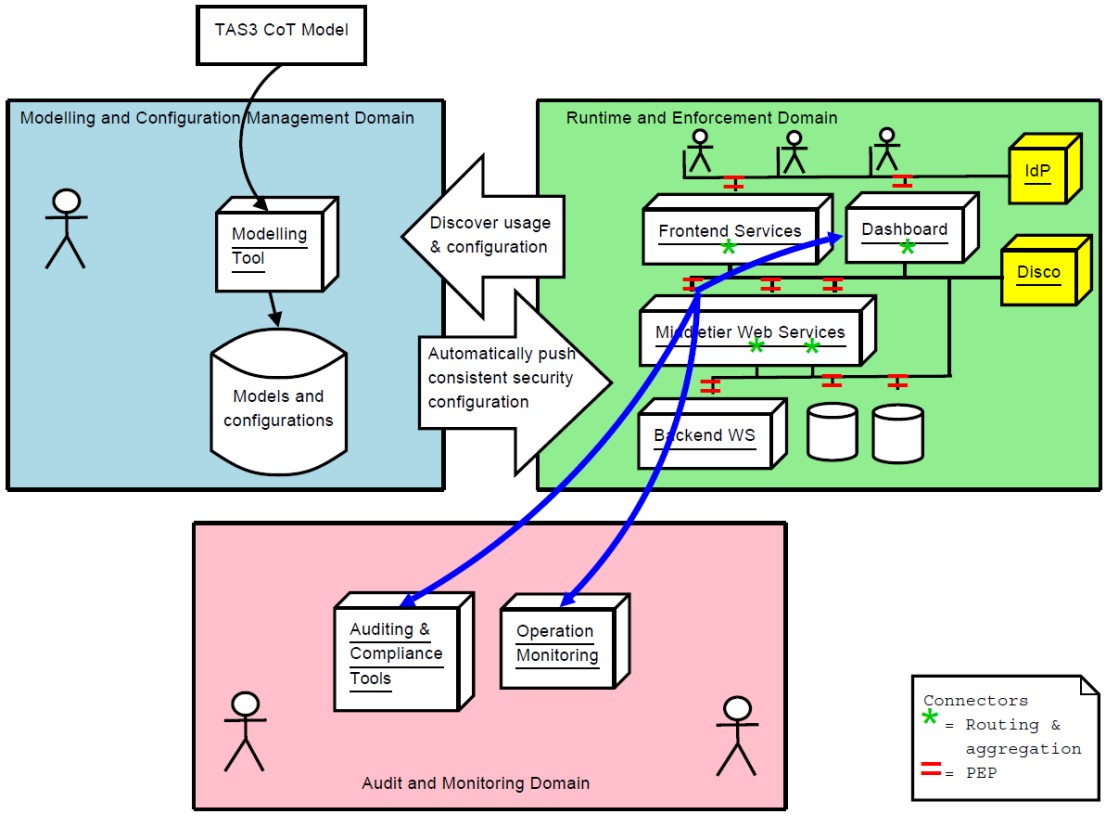


Figure 2.14: Monitoring operation of the network using the configured model.

3 Core Security Architecture

This section specifies much of the logistics that allow the identity of the user to be passed around between the architectural entities. This is a nontrivial problem, especially if pseudonymous delegated identity is to be supported, combined with recursive calls.

3.1 Flows

This section addresses Reqs. *D1.2-2.14-Priv, D1.2-2.15-Resp, D1.2-2.18-AnCredi, D1.2-2.19-AzCredi, D1.2-2.20-Az, D1.2-6.12-Sec, D1.2-6.17-TechBind, D1.2-7.3-An, D1.2-7.8-NoColl, D1.2-7.16-Nym, D1.2-7.21-Safe, D1.2-4.2-BPPrivacy, D1.2-4.4-CourtProof.*

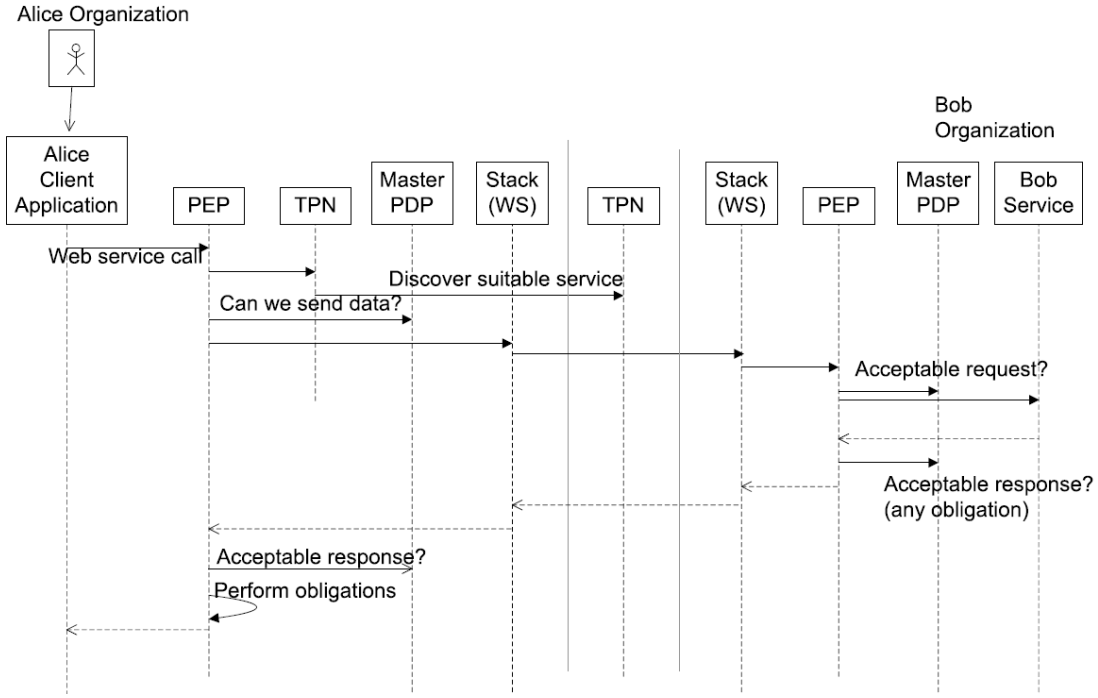


Figure 3.1: General detailed flow of a service request

Fig-3.1 shows the core flow.

1. A client application wishing to call some service in another organization, initiates the call.

2. The Client PEP will enforce outbound authorization decision. To be able to do this, it first engages in Trust and Privacy Negotiation, which is a discovery process, see Section 3.6, and then forwards the request to the web services stack.

3. Web services Stack (the "Stack") will compose a request message including the identity tokens that are needed and signs the message. It then send the message to the Stack on the service side.

4. The service Stack will authenticate the sending Stack and verify the digital signature. The acceptance of the message will depend on a degree of trust

on the signing party, which was established during the Trust and Privacy Negotiation.

5. The service inbound PEP will consult the Master PDP to determine if the service request should be allowed to go forward.

6. The inbound PEP will pass the request to the payload service, which will reply.

7. The outbound PEP of the Service will validate that the data can be released and attach obligations.

8. The Stack at the service correlates the response to the request, signs it and sends the response.

9. The client Stack receives the response, checks its correlation with the request, and verifies the signatures in the response.

10. The client inbound PEP checks that the response is authorized and complies with the obligations that were received.

11. The payload message is passed to the Client Application.

3.2 Tokens, Access Credentials

A central problem in multi-tier (or recursive) web services architecture is propagation of identity, or identity handle, to all tiers, while preserving privacy separation (resilience to collusion) between the parties.

The identity handle can allow, if chosen, linking of user's consequtive visits together so that the service can collect data about the user for future reference and provision of the service. In this case the user is persistently identified, but to preserve privacy, the user will be identified differently towards different parties. This prevents collusion by the parties.

Sometimes it is undesirable for the service to link relate visits of the user together. In this case user is identified transiently, i.e. by one-time pseudorandom identifier (Req. D1.2-7.18-Seq). Within one overall session, user can be identified persistently towards one service while at the same time transiently towards another service.

In general access credentials come in the form of tokens that are digitally signed by a system entity, usually a Trusted Third Party, such as an IdP or ID Mapper service. Reader can use SAML assertion [SAML2core] as a mental model, though this is not the only possible technology choice.

This section addresses Reqs. *D1.2-7.4-MultiCred and D1.2-7.18-Seq*.

3.2.1 Attribute Pull Model

> **Target model.** Fully capable. All use cases work and best privacy properties. This model has been extensively studied in Liberty Alliance standardization work (n.b. this does not limit its applicability to Liberty ID-WSF - same concept can be implemented using other web service specifications, albeit with lesser maturity). This model addresses minimal disclosure

particularly well, thus contributing to satisfying Reqs. *D1.2-2.14-Priv D1.2-2.21-DataProtLaw, D1.2-6.4-Min, D1.2-7.5-Min, D1.2-7.12-CredStepUp, D1.2-6.86-Min, D1.2-9.1-SecData.*

The Pull Model consists of front channel SSO layer and back channel web services layer. The "pull" refers to the strategy where attributes are requested from their authorative sources only on as needed basis. This has several benefits:

1. Minimal disclosure - only needed attributes are generated and shipped

2. Direct relationship with Attribute Authority. No intermediaries which could gain undue knowledge. This may also reduce crypto overhead as protection against the in-transit man-in-the-middle is not needed.

3. Intermediaries do not need to guess what attributes might be needed down the web services call chain or in a particular variant of a business process.

4. Fully dynamic and recursive operation that supports several Business Process Topologies. At least all forms of sequence (horizontal or vertical) and trees are supported. Support for a DAG would seem feasible. Other topologies need further study.

Use Case User U authenticates with a service provider A through her IdP1. A needs to invoke further service providers with reference to U.

Problem Definition If the trusted architecture uses a unique, even if random and transitory, userID throughout then such a userID would allow multiple parties to collude and correlate all data belonging to U.

Objective The system must avoid producing correlation handles in the process.

Solution Idea Each service provider knows the user by a different randomuserID, a persistent pseudonym. And these pseudonyms are held by a mapping service. When one service provider wants to pass on the request to another service provider, it can ask mapping service for a lookup of the pseudonymous userID in the target service provider.

Given that the user's pseudonym at the other provider is encrypted in transit, this solution avoids any service providers sharing correlation handles in the clear. (N.B. In this system the two service providers invoking each other's services are still able to directly collude by comparing the encrypted token that they have exchanged with each other, see Threat T107-LogTokLeak. The solution is to not log the tokens, see CR53-DontLogTok.) However, this would violate the previously stated audit principles. Furthermore, one service provider can obtain encrypted tokens for every other service provider from the mapping service, and pass these on, thereby being able to collude to correlate the user's account at each SP. We therefore conclude that there is no technical solution to the problem of collusion, and instead, the requirement to not collude to correlate a user's identity must be specified as part of the legal agreement of the trust network.

3.2.1.1 Front Channel

Trivial situation is when the payload application consists entirely of a web gui or web site, without any web services call. Never-the-less, this is a very important

flow because it is the most common way for Users to interact with the system. It is also a necessary precondition for the web services flows to be initiated and bootstrapped with the necessary tokens, including the IM access token.

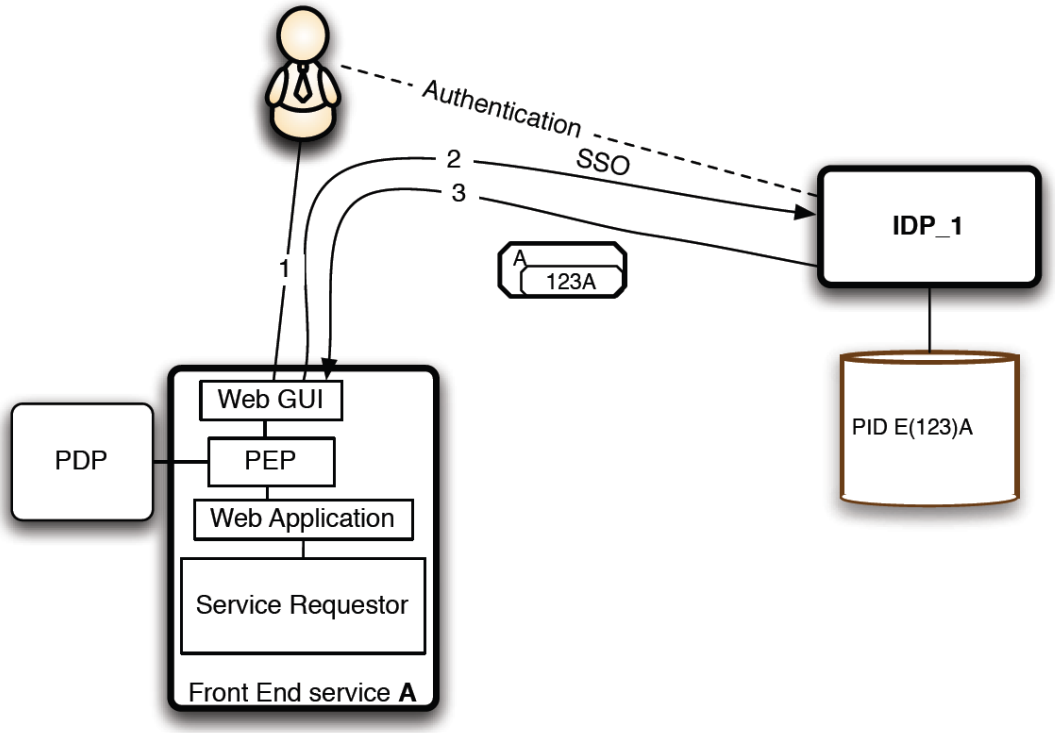


Figure 3.2: Flow at front channel

Example: In Figure 3.2 U authenticates and makes a service request to A.

Assumptions:

- IdP has a table that lists the user name and the password of the user.
- IdP passes the permanent userID with a given Service Provider to that Service Provider every time the user logs in to the IdP from the Service Provider. The identifier is conveyed in a token, e.g. `<username: sampo; attribute: member of tas3; other: permanent userID of user with different service providers>`

The Steps of the Protocol with one layer of Service Provider Invocations

1. User U wants to access service provider A and starts interaction with A.
2. U is redirected to IdP1 (n.b. IdP discovery is not addressed in this flow, though industry standards like [SAML2core] and [CardSpace] do address it)
3. U logs in at IdP1. The authentication method is out-of-scope for this flow.

IdP1 returns two encrypted tokens to A:

TokenAuthn the token contains U s permanent pseudonymous userID 123A4. It is encrypted such that only A can read it and authenticate the user.

TokenIM the token is encrypted for the IM and contains the permanent pseudonymous userID of U with IM which is 789IM. The token is bound to A (contains an indication that only A can use it towards IM).

A authenticates U with TokenAuthn (possibly Single Sign-On - SSO). If it is a stand alone service, A returns the results of the services to U and A is done.

3.2.1.2 Front Channel Using the Trusted Attribute Aggregation Service (TAAS)

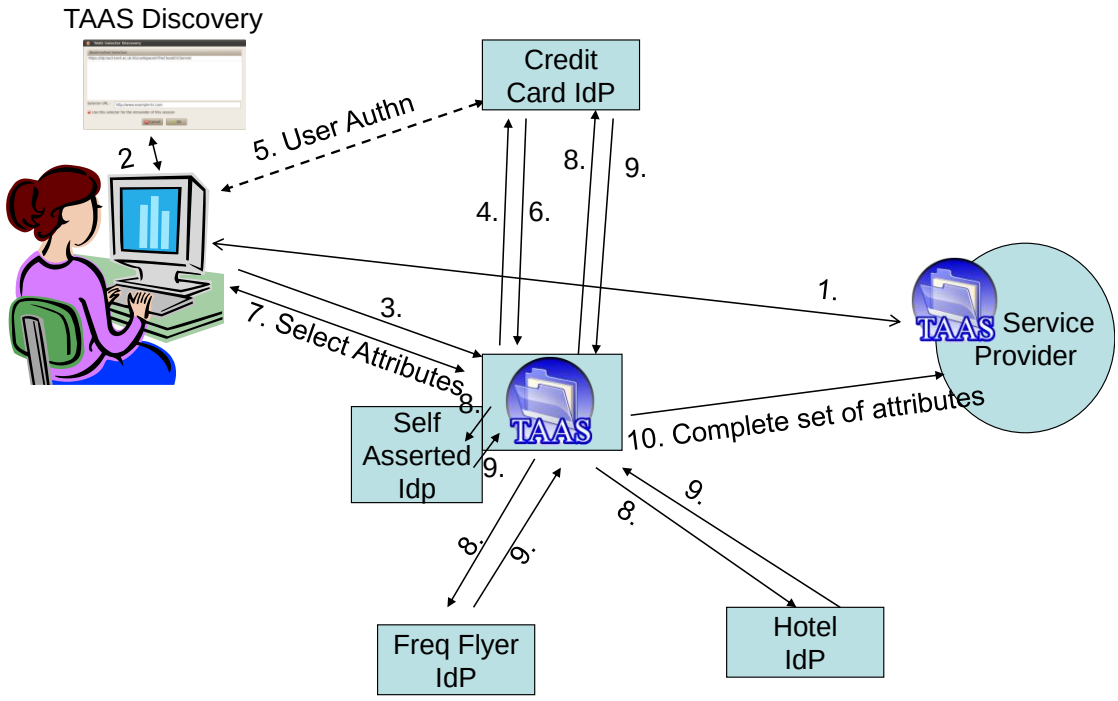


Figure 3.3 The Trusted Attribute Aggregation Service (TAAS)

TAAS is an enhancement of Microsoft's original Identity Selector technology which aimed at solving the IdP selection problem. The central proposal in the area was InfoCard, which was realized by Microsoft CardSpace and some open source Identity Selectors. InfoCard can be deployed in a direct fashion, but the problem has been availability of SAML 2.0 tokens. Other limiting factor is that it did not support attribute aggregation, and users found it difficult to use.

The TAS³ solution is to provide a new web service called the Trusted Attribute Aggregation Service (TAAS), which allows the user to choose which attributes from which IdPs should be sent to the Service Provider. TAAS provides a front end attribute selector to the back end Linking Service.

TAAS works as follows (see Figure 3.3). The SP displays its attribute policy to the user, and the user clicks on the TAAS icon to proceed (step 1). This causes the SP's policy to be sent to the user's browser as a newly defined MIME type. The browser calls the TAAS plug-in which has been registered to handled this MIME type, and the plug in asks the user to enter the URL of his TAAS (step 2). The

user can enter a new URL, or select one stored in his bookmarks. This solves two problems simultaneously - the IdP selection problem, as well as resistance to phishing attacks, since it is the user who decides which web service his browser should now contact.

The browser contacts the user's TAAS (step 3), and the TAAS asks the user to authenticate to it, as in Figure 3.2 above (steps 4 to 6). The IdP returns two authentication assertions to TAAS, one containing a random session identifier for the user in this session, and one containing the user's permanent identifier at TAAS. Once the user has been identified by his permanent identifier, the TAAS filters the SP's policy against the user's available attributes. TAAS displays each of the SP's attribute requirements to the user, along with his available attributes, asking the user to choose which of his attributes he wants to send to the SP (step 7). The user chooses the ones he wants, thereby providing consent, in line with data protection legislation.

TAAS now sends attribute requests to each of the user's IdPs (step 8), and they return attribute assertions encrypted to the SP (step 9), so that they are confidentially protected end to end. TAAS aggregates these responses and sends the combined set of attribute assertions, plus any user self-asserted attributes, plus the original authentication assertion from step 6, to the SP (step 10). Each of these assertions refer to the user using the same random session ID. The SP is thus able to verify that a) the user has been authenticated and b) the user does have the combined set of asserted attributes, without being given any persistent identifier for the user, thus preserving the user's privacy.

3.2.1.3 Back Channel, Simple

This flow expands on front channel by adding one web services call on back channel. This section addresses Req. D1.2-3.10-JITPerm.

Example: In our concrete example U authenticates and makes a service request to A which invokes another service provider B which also contains information about user U.

Assumptions:

- There is service provider IdMapper (IM). Each user usually has one IM that knows the permanent userIDs at the different service providers.
- IdPs know the IMs of the users (there are several ways to know. See section on user registration in this document to be written.)
- IdP/IM produce IM tokens. The IM tokens include the following information (which means this information is known to the IdP s and IMs):
- IM address
- the permanent pseudonymous userID of the user at the IM
- which service provider can use the token
- how many times and how long the token can be used (some of that could be pushed to a PDP attached to the IM, except the constraint about who can use it)

The Steps of the Protocol with one layer of Service Provider Invocations

1. (Same as above.) User U wants to access service provider A and starts interaction with A.

2. (Same as above.) U is redirected to IdP1 (n.b. IdP discovery is not addressed in this flow, though industry standards like [SAML2core] and [CardSpace] do address it)

3. (Same as above.) U logs in at IdP1. The authentication method is out-of-scope for this flow.

IdP1 returns two encrypted tokens to A:

TokenAuthn the token contains U s permanent pseudonymous userID 123A4. It is encrypted such that only A can read it and authenticate the user.

TokenIM the token is encrypted for the IM and contains the permanent pseudonymous userID of U with IM which is 789IM. The token is bound to A (contains an indication that only A can use it towards IM).

A authenticates U with TokenAuthn (possibly Single Sign-On - SSO).

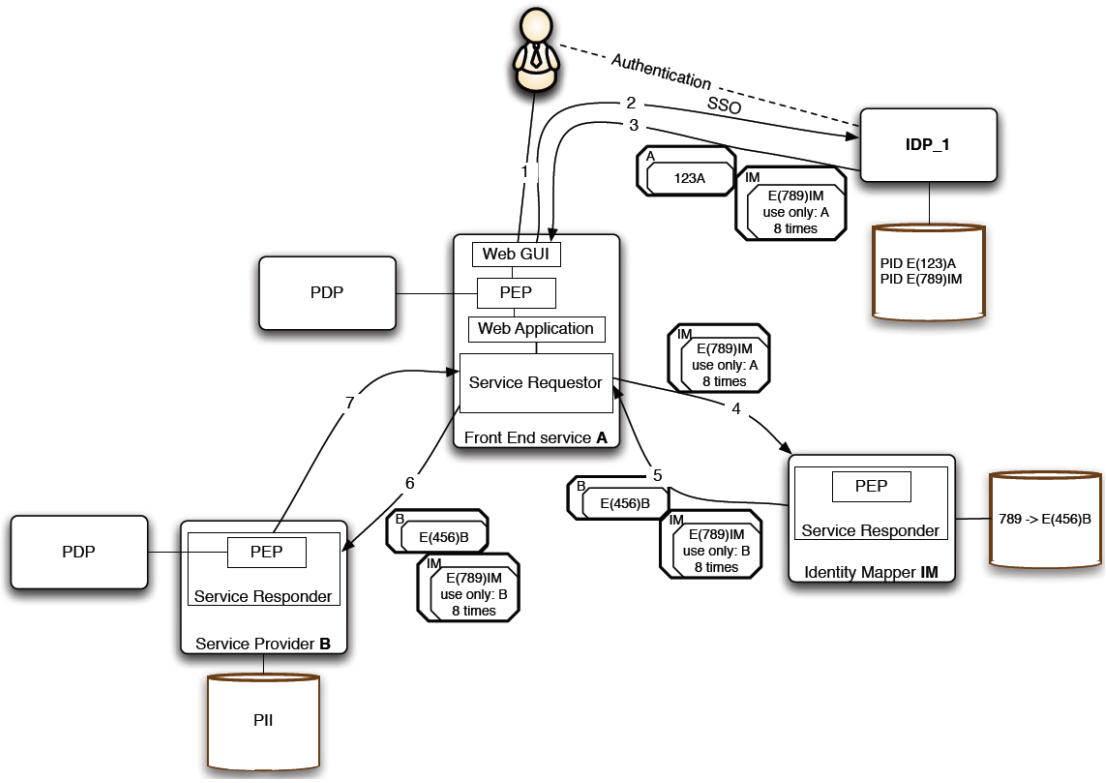


Figure 3.4: Flow of front channel call that makes a call on back channel.

4. A needs to use other service provider B to complete the services and needs the permanent pseudonymous userID for U in B. For this A passes TokenIM from IdP1 to IM.

The service provider B is selected based on Trust and Privacy Negotiator's efforts to find a suitably trusted SP from the database maintained by the IM (or some other part of the Discovery functionality). (Req. D1.2-3.10-JITPerm)

IM decrypts TokenIM from IdP1 and sees the user U registered as 789IM in its database. This with the token serves to authenticate the user to IM. Provided that the expiration time of the token is relatively short, the user can be assumed to be present (*User Present* scenario).

IM looks up the userID of 789IM for service provider B which is 456B (the lookup values can be in encrypted form).

5. IM encrypts two new tokens for the invoked service providers B and gives them to A.

TokenUIDinB the token is encrypted for B. The token contains the pseudonymous identity of user U at B. In this case it is: 456B.

TokenIM the token is encrypted for the IM and contains the userID of U with IM which is 789IM The token is bound to B.

6. A sends a request to B for a service for U and sends the two tokens from the IM.

B decrypts the token and recognizes the user as having UserID 456B in its database.

B sees that 456B is the user U . It calls the authorization function to see if U is authorized. Assuming the answer is granted, the service is provided.

If B needs to invoke further services with a service provider C it communicates with the IM of U using its TokenIM and repeats the steps 4 through 6. See the recursive case, below.

7. B returns a result to A which completes the service and returns result to user U.

If a User has multiple IMs, multiple IM tokens would be generated if there was no way to ask User's choice or other deciding rule to pick just one. This may result in practise nearly all IMs being aware of each other, but this need not always be the case and even partially populated IM matrix would remain useful to the user. Further, the IM matrix may be different for different users.

3.2.1.4 IM Bootstrap Token Minting and Passing through Front Channel

A key complication in the operation of the back channel is how to get the ball rolling, i.e. where do the first tokens come, before we can discover more tokens. The simple idea of just using the front channel token has undesireable privacy ramifications as it would provide a correlation handle between the SP and the discovery.

Such correlation handle can be avoided by bootstrapping procedure where the IdP provides a separate, encrypted, token for access to the discovery. Although SP will be an intermediary in passing the token to the discovery, it can not learn a correlation handle due to the encryption. Consider Fig-3.5 where the Single Sign-On (SSO) assertion (a7n), shown as red oval, is minted by the IdP, with another assertion, the discovery bootstrap token shown as blue ball, in it. The SP will establish session for the User (Principal) using the SSO assertion. When it

needs to call a web service, it will extract the bootstrap token and pass it to the discovery.

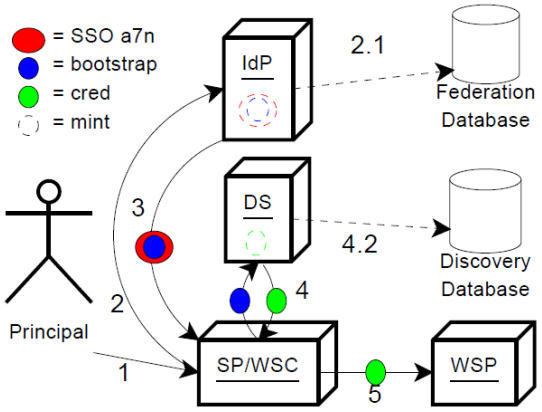


Figure 3.5: Single Sign-On (2,3), Discovery (4), and call to WSP (5). The blue ball represents discovery bootstrap.

One might ask how does the discovery know all the services the user has and what identity to include in the token. Many methods are possible, but ultimately the discovery maintains a federation database of pseudonyms at each web service for the user. This is very similar to what IdP maintains and it is not uncommon for IdP and discovery to be operated by the same organization.

One way to create the database is to bulk provision it.

Other way is to have user's actively register the services they consider theirs. Consider Fig-3.6 where user first (1) visits a service, perfoming a Single Sign-On, thus establishing his pseudonymous identity at the service. Then (2) user triggers the service to register itself as one of the user's services. At this point the discovery database records what it should send as users identity in a subsequent web service call. When the call is made, first the discovery step (4) is made to obtain the token and then (5) the actual web service call with the correct identity.

3.2.1.5 Improvement Idea: Late IM Token Request

> N.B. The IM does not get used at the last step of the chain. It has to produce n + 1 tokens for n invocations. This introduces a slight inefficiency.

An improvement of the efficiency of the process is as follows:

Each service provider is only given the authn token and is not given the IMtoken. If the service provider can provide the service then no IMtoken is needed. If the service provider needs to contact another service provider, then it contacts the IM to ask for the ID of the user at the next service provider. It refers to the user using the permanent ID by which the user is known to the IM and itself (e.g. 456B for B or 123A for A). In this case 789IM is never known to any of the service providers and is internal to the IM. The IM can use the permanent ID to look up the user, find its local ID (789) then locate the permanent ID at the next service provider and send this encrypted for the next service provider, back to the requesting service provider for it to forward to the new service provider.

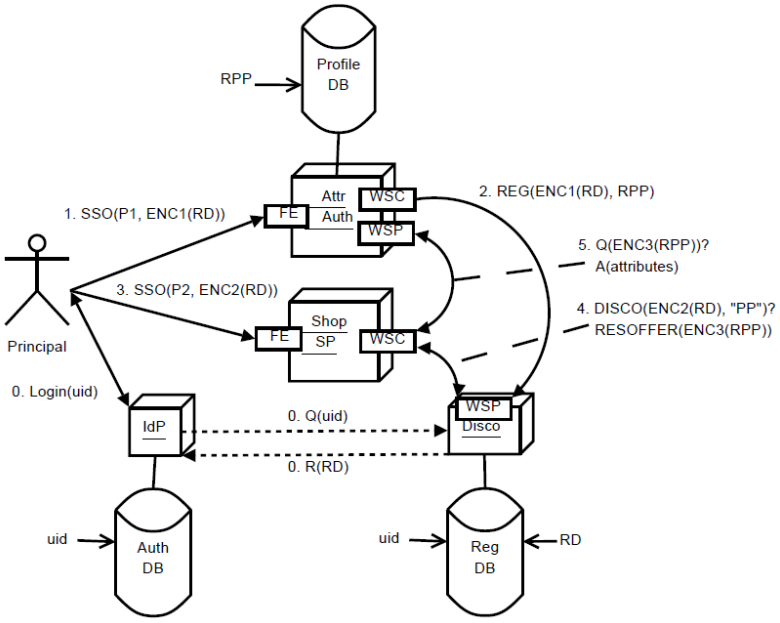


Figure 3.6: Discovery Registration Using Front Channel Interface.

Problems with this approach: if there are multiple IMs, the service provider will not know which one to contact. If there is only one IM, this is ok. But, the protocol is not standard. Where as the protocol we defined above is a standard Liberty Alliance protocol.

3.2.1.6 Back Channel, Recursive

The Steps of the Protocol with one layer of Service Provider Invocations

1. (Same as above.) User U wants to access service provider A and starts interaction with A.

2. (Same as above.) U is redirected to IdP1 (n.b. IdP discovery is not addressed in this flow, though industry standards like [SAML2core] and [CardSpace] do address it)

3. (Same as above.) U logs in at IdP1. The authentication method is out-of-scope for this flow.

IdP1 returns two encrypted tokens to A:

TokenAuthn the token contains U's permanent pseudonymous userID 123A4. It is encrypted such that only A can read it and authenticate the user.

TokenIM the token is encrypted for the IM and contains the permanent pseudonymous userID of U with IM which is 789IM. The token is bound to A (contains an indication that only A can use it towards IM).

A authenticates U with TokenAuthn (possibly Single Sign-On - SSO).

4. A needs to use other service provider B to complete the services and needs the permanent pseudonymous userID for U in B. For this A passes TokenIM from IdP1 to IM.

The service provider B is selected based on Trust and Privacy Negotiator's efforts to find a suitably trusted SP from the database maintained by the IM (or some other part of the Discovery functionality).

IM decrypts TokenIM from IdP1 and sees the user U registered as 789IM in its database. This with the token serves to authenticate the user to IM. Provided that the expiration time of the token is relatively short, the user can be assumed to be present (User Present scenario).

IM looks up the userID of 789IM for service provider B which is 456B (the lookup values can be in encrypted form).

5. IM encrypts two new tokens for the invoked service providers B and gives them to A.

TokenUIDinB the token is encrypted for B. The token contains the pseudonymous identity of user U at B. In this case it is: 456B.

TokenIM the token is encrypted for the IM and contains the userID of U with IM which is 789IM The token is bound to B. A sends a request to B for a service for U and sends the two tokens from the IM.

6. B decrypts the token and recognizes the user as having UserID 456B in its database.

B sees that 456B is the user U . It calls the authorization function to see if U is authorized. Assuming the answer is granted, the service is provided.

7. In course of providing the service, B wishes to call the user's Role Authority (which is offered by C). This is termed "recursive call" and such pattern can occur to any depth. B starts by discovering service of type "Role Authority", sending the IM token to the Identity Mapper.
8. The IdentityMapper decrypts the IMtoken and recovers the pseudonymous persistent ID 789IM, which is then used to locate from the database of IM the pseudonym of the User at service C, which is the only service of type "Role Authority" registered for the User. Identity Mapper returns two tokens: (i) the pseudonym of user at C encrypted such that only C can open it ("E(fgh)C" in figure), and (ii) IM token that C may use to make further web services calls.
9. B calls C, passing the tokens along.
10. C decrypts the token "E(fgh)C" and recovers the persistent pseudonym "fgh". It uses this key to look up the role from the database and returns it to B.
11. B uses the role to authorize the request (6) and returns a result to A which completes the service and returns result to user U.

Steps 7 through 10 can be repeated any number of times in a recursive fashion.

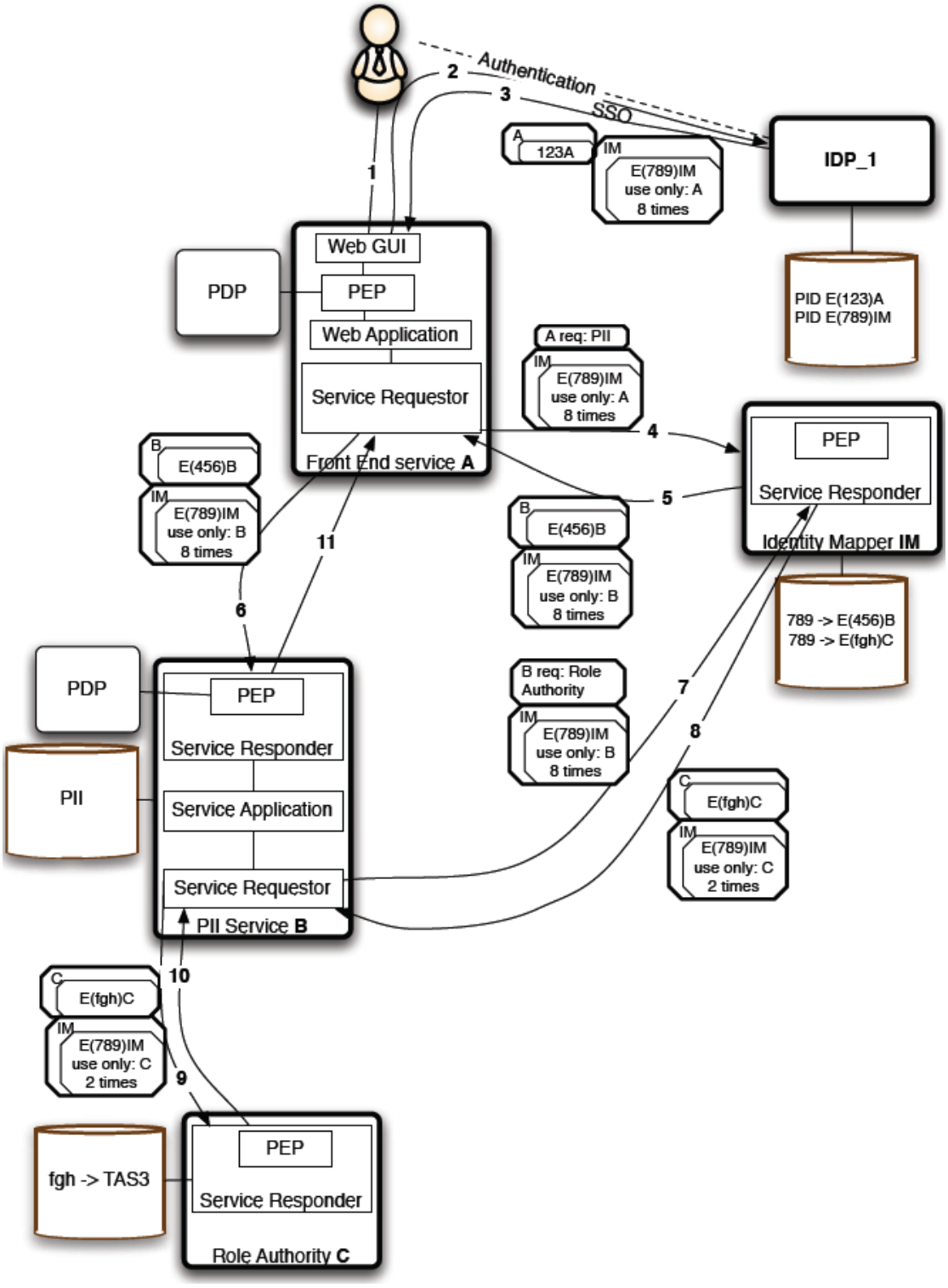


Figure 3.7: Flow of recursive calls on back channel.

3.2.2 Linking Service: Attribute Push Model

This section addresses Req. D1.2-7.15-PushCred.

The Linking Service model is described more fully in [TAS3D71IdMAnAz]. We just give a brief summary of the model here.

The Linking Service model is based on the following assumptions/requirements:

- users typically have multiple attributes (authorisation credentials) assigned by multiple authorities and they are known by different identifiers at each authority
- some service providers will require many of these credentials in order to grant access
- the user does not want the inconvenience of having to authenticate (login) to each of the attribute authority in order to obtain credentials to give to the service provider
- the service provider does want strong cryptographic evidence that each of the authorisation credentials does belong to the user who has initiated the session
- the user should be able to set up his policy for which attributes are aggregated by which SPs
- the user should be able to provide consent each time his attributes are aggregated by an SP.

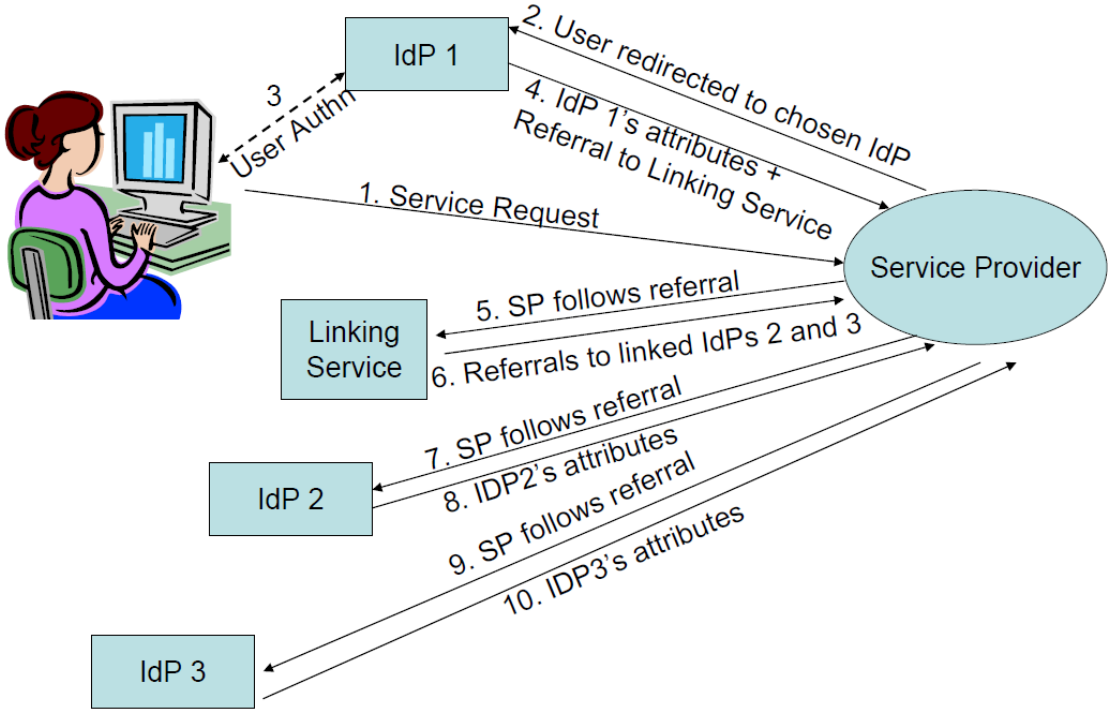


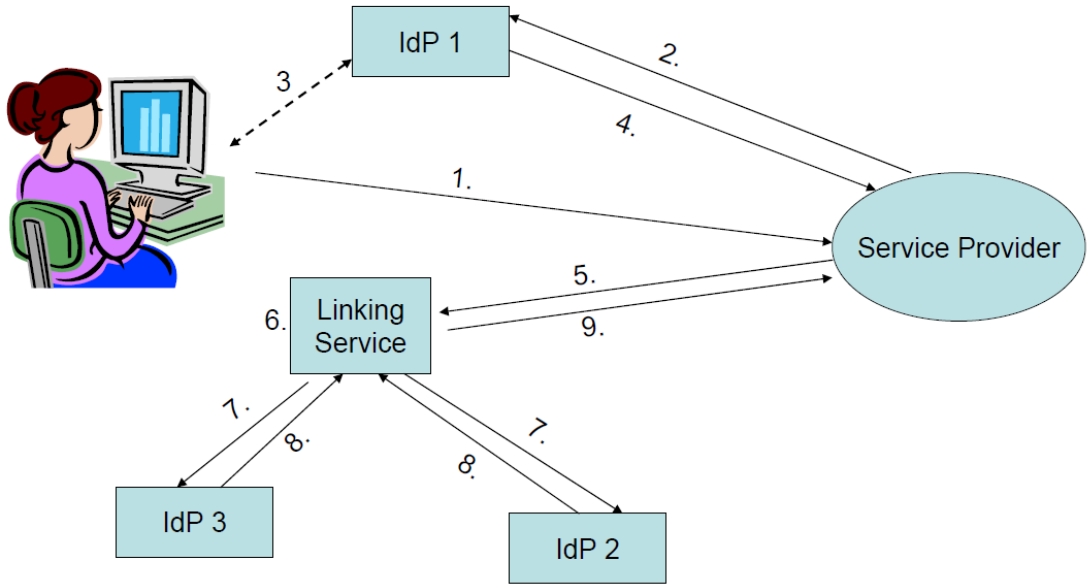
Figure 3.8: Linking Service: Registration phase.

The Linking Service is a new component that is under the control of the user, and allows the user to set his link release policy for which of his IdPs may be linked together so that their attributes can be aggregated and sent to the same SP. The user may in addition set an attribute release policy at each of his IdPs that is authoritative for more than one attribute, to say which SP can receive which subset of his attributes from this IdP. Taken together, the link release policy and the set of attribute release policies give the user complete control over which of his attributes can be aggregated together and released to which service providers. The GUI for the link release policy has already been described in

Section ??. The GUI for the attribute release policy will be very similar to this, but instead of associating IdPs with SPs, the user will associate attributes with SPs. Note that in many cases attribute release policies will not be needed since most IdPs are typically only authoritative for one attribute.

Once the user has linked his IdPs together and set his link release policy at the Linking Service, the user contacts an SP for a service. The front channel steps are as follows

1. User contacts SP asking for a Service
2. SP and/or user interact, allowing IdP choice as usual
3. User is redirected to chosen IdP and Authentication with the IdP takes place as usual
4. In addition the User can tick a box giving consent for attribute aggregation to take place in this session (see Fig-3.10)



1. User makes a service request. **2.** User is redirected to her chosen IdP **3.** User authenticates to IdP 1. **4.** IdP 1 returns an authentication statement + attribute assertions + referral to linking service **5.** SP follows referral **6.** Linking service looks up IDP 1:PID 1 of user and finds links to other IdPs. **7.** Linking service requests attributes from linked IdPs using respective PIDs **8.** IdPs return signed and encrypted (to SP) attribute assertions. **9.** Linking service relays all attribute assertions to SP.

Figure 3.9: Linking Service: Login with attribute push phase.

5. User is redirected back to SP and is granted access to the service.

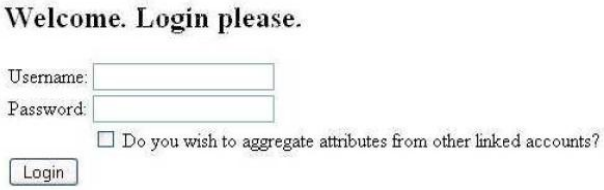


Figure 3.10: The enhanced login screen for attribute aggregation.

The back channel communications that take place between steps 4 and 5 above are as follows:

1. The IdP sends an authentication SSO statement to the SP, containing a random identifier for the user. This prevents the SP from correlating the user's requests in different sessions. (Note that if the user wishes to be correlated he can arrange for the linking service to send a unique identifier attribute from one of his attribute authorities during the attribute aggregation process, for example, a National Health Number from the Health Authority if the SP is a medical application, or a unique ID from the authenticating IdP). The IdP also sends an attribute statement containing the user's attributes at this IdP, and an attribute statement containing referral(s) to the user's linking service(s). Each referral contains the unique ID of the user as known by the Linking Service and it is encrypted to the public key of the Linking Service.

2. The SP acts on the referral(s) and contacts the LS's discovery service asking it to return the linked IdPs' discovery services, along with a Boolean saying "I will do it or You do it for me".

3. The LS decrypts the unique ID of the user, looks this up in its database and finds all the user's linked accounts. If the SP has asked to perform aggregation itself, the linking service returns a Response containing referrals to the discovery services of the user's linked IdPs.

4. The SP now sends a query message to each of the IdP's discovery services, requesting the contact details of the user's attribute authority. Alternatively, if the linking service is performing the aggregation on behalf of the SP, it sends the same message to each IdP.

5. The IdP's discovery service locates the user's local account by decrypting the user's unique ID in the referral, and maps the random identifier from the authentication assertion into the user's local account id. The IdP returns a Response containing the contact details of the attribute authority where the random identifier is now valid

6. The SP or linking service sends an Attribute Query message to the attribute authority, using the random identifier, whereupon the attribute authority returns a digitally signed attribute assertion encrypted so that only the SP can read it.

7. If the linking service is doing the aggregation, it collects together all the encrypted responses from all the IdPs and then forwards the complete package to the SP.

8. The SP now has the following digitally signed assertions:

a. An authentication assertion from a trusted IdP saying that the user has been authenticated, and is to be known by this random id for this session

b. A set of attribute assertions from trusted attribute authorities saying that the user known by this random id possesses this set of attributes

c. Based on the above the SP can authorize the user to access the requested resources, sure in the knowledge that trusted authorities have both authenticated the user and assigned attributes to her.

3.2.2.1 N-Tier Linking Service Model

This section addresses Req. D1.2-7.1-Deleg.

If the SP above needs to subcontract one or more tasks to a backend service, and that backend service is to act from an authorization perspective as if the user herself had contacted it directly, then the backend service will need to be given the user's authorization attributes. Whilst there have been many previous models for dynamic delegation of authority none of them to the best of our knowledge have supported attribute based delegation simultaneously with privacy protection of the delegator's and delegate's identities. We have solved this in TAS³ by the process of delegation by invitation (see section 3.3.1 below and section 6.3 in D7.1).

The user contacts a delegation service and delegates her attributes to the first SP, bestowing these credentials with delegation rights. The first SP uses these credentials to authorize the user, and then delegates them further to the backend SP, optionally bestowing further delegation rights on the backend SP in case it needs to subcontract further. The advantage of this model is that the backend SP does not need to trust the first SP, since the latter has specifically been delegated rights to it by the user. By combining the linking and delegation services to work together in a trustworthy manner we allow the user to delegate attributes from multiple IdPs to an SP.

3.2.3 Simple Attribute Push Model

> **Recommended** approach for initial deployments that have not yet developed full infrastructure.

In this model some commonly needed, or "enabler", attributes such as Trust Network membership or role are supplied directly as part of Single Sign-On (SSO) or web service tokens. Other perhaps justifiable attributes, that do not provoke overdue privacy or legal implications, could be

- legally nonbinding nickname for greeting user
- user's preferred language

This model implies that IdP or IDMapper assume some of the responsibilities of an Attribute Authority. This is well supported in existing protocols and available software implementations. It is also probably the largest operation model in use today in existing federations. For example, this is the model used by all Shibboleth implementations such as the UK academic community federation which has over 800 IdPs and SPs since it was launched in August 2008.

Drawbacks of this approach are

1. Only a very narrow set of attributes will be universally needed by nearly all Front Ends orWeb Services.

2. Danger of nonadherence to minimal disclosure principles - its easy to have creep where "just one more" attribute is added to support "just one more" application. This is also wasteful in that cost for generating attribute statements that are seldom needed is still paid on every transaction.

A solution to this is to have an Attribute Release Policy (ARP) at the IdP which provides rules for which attributes should be released to which SPs. In this way the attributes can be effectively filtered before release. The ARP is set by the user and/or the IdP itself, and open source software does exist for this. The design is very similar to the IdP Release Policy of the Linking Service described in Section 3.2.2, above. Still, this approach lacks granularity as the attribute needs of a SP are assumed to be always the same, while in reality SP may run various different business processes with different needs.

3. Postponement of moving to full pull model.

3.3 Delegation

This section addresses Reqs. D1.2-3.7-Deleg and D1.2-7.1-Deleg.

> Technical clarification: Here "Delegation" means assignment of one User's privilege attributes, and the access rights they imply to another User. This is distinct from merely instructing some web application or service to login on one's behalf - some other practitioners call also this "delegation", but we call this masquerade since the service cannot tell the difference between the real user and the so called delegate. This is so common that it is the base case, and does not need special mention.
>
> It should be noted that some system entities may be modelled as juridical persons and can, thus, participate in Delegation like the Users can.

General properties of delegation are

- Express and auditable act of delegation, with indication of registration (where needed).
  - Specification of delegatee
  - Specification of delegator
  - Specification of scope
  - Attribute to be delegated (exceptionally a specific task may be delegated)
  - Specification delegation constraints such as expiry time and other policy constraints such as SPs at which delegated tokens can be used.
- Specification of recursion i.e. (if delegate can recursively delegate, and if so, to what depth)
- Ability to revoke, with extent to which this is possible, such as
  - At any step of sub-delegation chain

- Any superior ancestor can revoke any descendant

- Verification by Relying Party based on presented delegation tokens
- Transparency: ability for user to verify which delegations have in fact been exercised or formally accepted.

This could be implemented by the Delegation Service feeding information about each invitation usage to the Audit Event Bus, where the Dashboard picking up the information and displaying it to the delegator when he/she comes to consult it. Also, when a Service Responder, or its CVS or PDP, consumes a delegation token, it will inform the Audit Event Bus so that the Dashboard can have the big picture of the delegation usage.

Delegation is also discussed in section 6 "The Delegation Service" of [TAS3D42Repo] and in section 6 of Deliverable D7.1 [TAS3D71IdMAnAz].

Designation of Delegatee may be by

- Delegation to anyone (or first one) possessing an invitation token
- Delegation to someone specific

  - How is the someone to be identified? Well known unique ID is an option.
- Delegation to anyone having a specific role
- Delegation to anyone having some relationship to the Delegator
- Delegation to anyone having some relationship to previous tasks, business process steps, or environmental context (e.g. physical access).

It is important that delegators be able to revoke any delegations that they have initiated. However, whether a delegator can revoke any delegates of his delegates – so called cascading revocations - depends upon whether the delegation service keeps a full history of the delegation chains or not.

3.3.1 Invitation Based Token Approach

TAS³ has implemented the Delegation by Invitation method, using a Delegation Web Service. The steps involved in the delegation by invitation method are as follows:

1. The Delegation Service identifies the delegator
2. The Delegation Service checks that delegator has the attribute(s) he wishes to delegate and that he is allowed to delegate it (them) to anyone
3. The Delegation Service issues and invitation token to the delegator
4. The Delegator gives the invitation token to the chosen delegate
5. The Delegate contacts the Delegation Service, authenticates to it via his chosen IdP and presents the invitation token
6. The Delegation Service validates the invitation token and confirms that the delegate has all the necessary attributes

7. The Delegation Service confirms the delegation and stores the delegated attribute along with the delegate's newly created entry.

8. The Delegation Service is now able to issue the delegated attribute to the delegate whenever he authenticates and asks for it.

Further details about the Delegation Service can be found in D7.1

3.3.1.1 Reuse of Invitation Token

One salient property of this delegation by invitation method is that the invitation token may be requested by the delegator for one time use or multiple use. For one time use, once the invitation token is presented by a delegate, it is discarded by the Delegation Service and thereafter cannot be presented again. Any subsequent attempts to present the same invitation token will fail. However if multiple use is requested, the delegator can give the invitation token to multiple delegates, and each one can present it to the Delegation Service. Each delegate will be asssigned the delegated attribute and the invitation token will remain valid. The invitation token will cease to be valid after a certain amount of time or after a certain number of uses. Note that with multiple use, the delegator can only revoke all the delegates, or none. It is not possible to revoke individual delegates since they were all delegated via the same invitation token. This is not the case with one time use, as each delegate can be individually revoked.

3.3.2 Delegation by Direct Authorization Rule

In this model the resource owner (delegator), knowing the delegate's full set of identity attributes, creates an access control rule at the resource that simply authorizes anyone with these attributes to access the resource.

The ability to assign access to other users can be regulated by policies that are checked by the sticky policy interface, e.g. by consulting a PDP.

When a delegate accesses the resource, he identifies himself using the usual token passing flow, and his identity attributes are given to the resource. The resource's PDP is able to match his identity attributes to the policy authorizing the access and grant access.

In its basic form the ABAC model allows the holder of any identity attributes to access any resource that accepts the attributes and the identity (identifier) of the role holder is irrelevant, thus permitting use of pseudonyms or transient identifiers that improve the privacy.

3.3.3 Delegation to Well Known Delegate

If the Delegate can be uniquely identified by the delegator, the delegator can instruct the Delegation Service to create a signed (by Delegation Service) token specifically for the delegate. This is the case for example, when users are identified by LDAP distinguished names or SPs have well known URLs. Since the TAS³ infrastructure is based on the use of pseudonymous and random identifiers to identity human users, then the approach of using unique identifiers will not be adopted for human users. It can be easily adopted for identifying SPs, as a choice of the application user interface.

3.3.4 Multi-layer (Chained) Delegation

The attribute based delegation methods described above lend themselves to multi-layer (chained) delegation. In this case the delegation is made with the right to sub-delegate and the delegate is able to request that further delegation invitation tokens are created, which can be passed to the next delegate in the chain. The length of the delegation chain is initially controlled by the original delegator, but subsequent delegators in the chain can shorten the chain if they wish. Note that it is never possible to increase the length of the delegation chain that has been set by the original delegator.

For access authorization, when a delegation service is used, only the last step of a delegation chain is important, but for audit purposes the full chain is needed.

3.4 Break-the-Glass Authorization

This section addresses Reqs. D1.2-3.9-BPRecover, D1.2-4.6-BrkGlass, and D1.2-7.22-BrkGlass. See [TAS3D71IdMAnAz] for further discussion of the Break-the-Glass authorization.

In a Break-the-Glass scenario an operation would not normally be authorized given the actor and the resource (including owner of the resource), but given justified and legitimate imperative need, the operation is authorized, usually with additional auditing enabled.

A classical example would be an unconscious patient brought to an emergency ward. The physician has imperative need to access the patient records, yet the patient cannot consent to the access.

The TAS³ approach is as follows

State driven Break-the-Glass: In this approach the authorisation infrastructure records the state of the glass, whether it is broken or not. Glass state is multi-dimensional and can be assigned to any attributes of the authorisation decision request e.g. per subject, per action, per resource, per day etc. The user attempts access to the resource, and the PEP attempts authorization, which fails. The PDP returns a new “BTG” response to the PEP. The PEP proceeds to ask consent from the user ("Do you want to invoke Break-the-Glass privileges and additional auditing?") using the interaction facilities of the architecture. If the user answer is Yes, then the PEP sends a Break the Glass request to the authorisation infrastructure, which then sets the appropriate glass state to broken. After this the user may access the resource as normal.

Enabling Break-the-Glass forces additional audit messages to be generated at the PEP and by the service overall. There will also be an audit entry on the PDP side, permitting better cross correlation of the audit trails. Break the Glass is described more fully in section 3 of D7.1.

3.5 Trust and Privacy Negotiation

This section addresses Req. D1.2-7.17-Increm.

The purpose of trust and privacy negotiation is: to determine whether or not the web service client (WSC) and the SP possess the required attributes (authorization credentials) in order for the WSC to access the service (i.e. to enable the WSC and the SP to establish mutual trust); and in cases where both the WSC and the SP do possess the required attributes/credentials, which subset of them, disclosed by the WSC to the SP, is sufficient to grant access to the resource.

We have developed a special form of credential disclosure policy which we call 'CUP' (for "COSIC UniPro"), and extended the TrustBuilder2 framework [TrustBuilder2]. CUP policies are based on the UniPro approach [UniPro] of automated trust negotiation. UniPro allows SPs (and WSCs) to partially disclose access control policies, so as to facilitate progress in the negotiation protocol. The concrete protocol and implementation mechanics are described fully in sections 11 and 12 of D7.1

3.6 Interoperation across Trust Networks

The general approach for interoperation across Trust Networks is described in [LibertyInterFed], which focuses on the token passing flows in an inter-federation situation. In addition to token passing, interoperability at the data level is needed, i.e. the ontologies in use in the different Trust Networks either need to be the same or they need to be mapped. In particular, authorization critical data needs to be mapped.

3.6.1 Semantic Interoperability – OBIS the Ontology-based Interoperation Service

This section satisfied Reqs. *D1.2-2.23-SemIOP, D1.2-3.14-PIIPolicyDisco, and D1.2-3.15-SecPreserve.*

One of the main challenges of TAS³ is to guarantee the correct interpretation and implementation of data protection policies, while sharing, accessing, and using information processing services in federated environments. These are essential elements of trust that are required for various stakeholders, especially end-user, to participate in any implementation of the TAS³ architecture. As new service providers join a TAS³ federation, with new policies that are protecting their resources and new credentials that are assigned to their users, it cannot be guaranteed that all federation members will use the same terminology for the same concepts. To solve this, some federation have mandated that all members use the same vocabularies, credentials and policy terms. But this is unrealistic in large scale multi-national federations.

The TAS³ approach is, instead, to introduce an ontology-based interoperation web service (OBIS). This is configured with the vocabularies of all the service providers, and consequently is able to calculate the dominance relationship between two security concepts inferred from an access request term and a local authorization policy term, based on the generic ontology-based data matching framework (ODMF) [ODMF]. The OBIS web service differs from existing approaches by providing a method for the association of policies and controls from all the service providers in a federated system and being integrated into the

authorization infrastructure. In the proposed approach, every stakeholder expresses his authorization policy using his own vocabulary, and when a policy engine receives an authorization request containing an unknown term, it semantically matches this to one that is locally known by the authorization policy. This linguistic-based approach is adopted in the privacy domain in order to allow different non-technical users (and organizations) to express their security policies in an intelligible way, through the use of natural language, thus enforcing the user-centricity aspect.

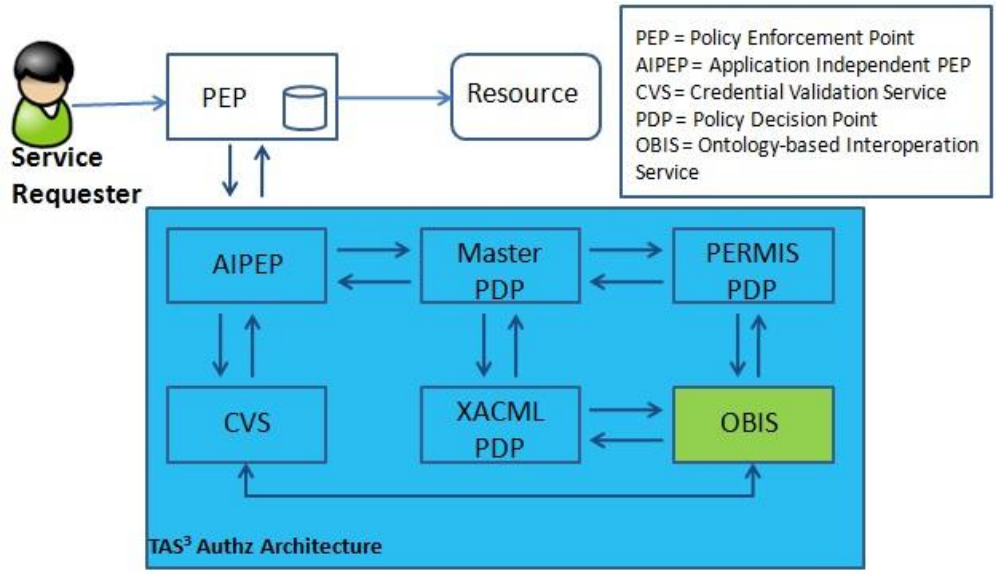


Figure 3.11. Authorization Architecture

The OBIS service, described in deliverables D2.2 and D7.1, is located in the authorization infrastructure as shown in Figure 3.11. The authorization process consists of the following steps. The Service Requester (SR) launches a request to access a resource protected by various authorization policies. The resource's Policy Enforcement Point (PEP) intercepts the request and passes it to the Application Independent Policy Enforcement Point (AIPEP). This initially contacts the Credential Validation Service (CVS) to validate the requestor's credentials (i.e. attribute claims) which typically have been issued by multiple different attribute authorities in the federation (not shown in Figure 3.11). The CVS uses its local credential validation policy to determine which credentials are valid. If the CVS cannot validate any credential, it contacts OBIS to determine the relationship between the presented attributes and the ones in its policy. Based on the domination relationship returned by OBIS, the CVS is able to return the set of valid attributes to the AIPEP. The AIPEP now contacts the Master PDP, passing the valid attributes, and asking for an access control decision. The Master PDP calls the set of subordinate PDPs which support different access control policy languages (e.g. XACML and PERMIS). This ensures that all service providers do not need to support the same policy language, and that policies in different languages can be passed between providers and still enforced by them. If a PDP is not able to make an access control decision, then it calls OBIS to calculate the semantic relation between

terms in the access request. Based on the values returned by OBIS, the access request is either granted or denied.

3.7 Properties of Web Service Binding

Web Service Binding is a set of features that the communications layer is assumed to have. These features are often required by more sophisticated protection mechanisms like the token passing flows. They often address basic and well known threats like replay, unauthorized, and man-in-the middle attacks in a basic way while other mechanisms may address the same topics comprehensively, but in a more expensive way. Many of these features may seem self-evident, but we need to list them even if just to state the obvious.

1. Mutual authentication of the communicating entities MUST be possible. Usually this is done using transport layer digital certificates, but other approaches are possible.
2. Link confidentiality MUST be possible, usually using transport layer encryption.
3. Correlation MUST be possible
   - Request-Response Correlation
   - Business Process identification in correlation
4. Redirection should be supported for flexibility
5. Re-credentialing MUST be supported (Req. *D1.2-3.9-BPRecover*)
6. Asynchronous message passing SHOULD be suppoted
7. Interaction Callback (or Exception Request)
   - Interaction Redirect (Req. *D1.2-3.9-BPRecover*)
   - Interaction Service (Req. *D1.2-3.9-BPRecover*)
8. Digital signing of messages for nonrepudiation (Reqs. *D1.2-2.11-Transp, D1.2-2.15-Resp, D1.2-4.4-CourtProof*)
9. Conveyance of Invoker and Target Identities, if web service uses identity.

4 Application Specific Architecture

4.1 Protocol Support for Conveyance of Sticky Policies

Most of the protocol flows of TAS³ use industry standard Web Services bindings and Web Services payload protocols. It is an explicit design goal that existing services are enabled with minor disruption.

A pertinent problem with existing payload service protocols is how to express the sticky policies that generally have to be bound to the data with a digital signature. Following approaches have been identified

1. Treat all data in one request-response pair as having the same Sticky Policies. In this cases relatively nonintrusive methods like SOAP headers and LDAP controls can be used to indicate the sticky policies. We call this Security Header (SH) approach. This approach is already available as <UsageDirective> SOAP header defined in [IDWSF08].

2. Use the extension points of the payload protocol to express the Sticky Policies. We call this approach Application Protocol Enhancement (APE), see [TAS3D71IdMAnAz] section 8.2. This approach gives granular Sticky Policies that are naturally associated with the data and does not alter the top levels of protocol processing. If the client and server are updated to understand this scheme then it works well. Eventually new payload protocols should be specified with TAS³ APE feature built in. A danger of this approach is that if the client is not updated, it may just silently ignore the Sticky Policies. However conformance testing will solve this problem.

3. Expand the data model to carry sticky policies. This is really a special case of APE with similar merits and problems. One benefit is that it is sometimes easier to extend a datamodel than a protocol.

4. Encapsulating Security Layer (ESL), see [TAS3D71IdMAnAz] section 8.2. Wrap the payload protocol in a TAS³ defined encapsulating protocol that contains all the TAS³ specifics and in particular the sticky policies. Advantages of this approach include

- The encapsulated protocol does not need to be modified at all
- Possibility to add sticky policies to protocols that do not offer extension points and that are not under control of the implementer.

Disadvantages of this approach are

- More invasive on outer layers of the protocol stack. This may make it difficult to integrate to existing protocol stack.
- If the payload protocol is not SOAP, or otherwise has poor impedance match to the TAS³ ESL protocol, then integration may be impossible.
- Association of the sticky policies to the data will require awkward correlation of data items to the policies. In particular, if the data does not

have item specific IDs, it may be necessary to resort to use of techniques such as [XPATH99].

Given the multiplicity of approaches, each with its merits, the problem arises as to which one should be used. Luckily all can coexist in the same Trust Network. This is made possible by expressing different approaches as different Service Types so that it is possible to discover services that make the approach supported by the client possible. Another approach is to use autodetection, observing the namespaces and elements passed in the SOAP payload to determine which one is being used.

Which of the approaches works best will be determined by each of the pilot demonstrators.

4.2 Legacy Integration Strategy

For the TAS³ architecture to be useful, it needs to be widely adopted. To adopt TAS³ an existing application faces some implementation choices.

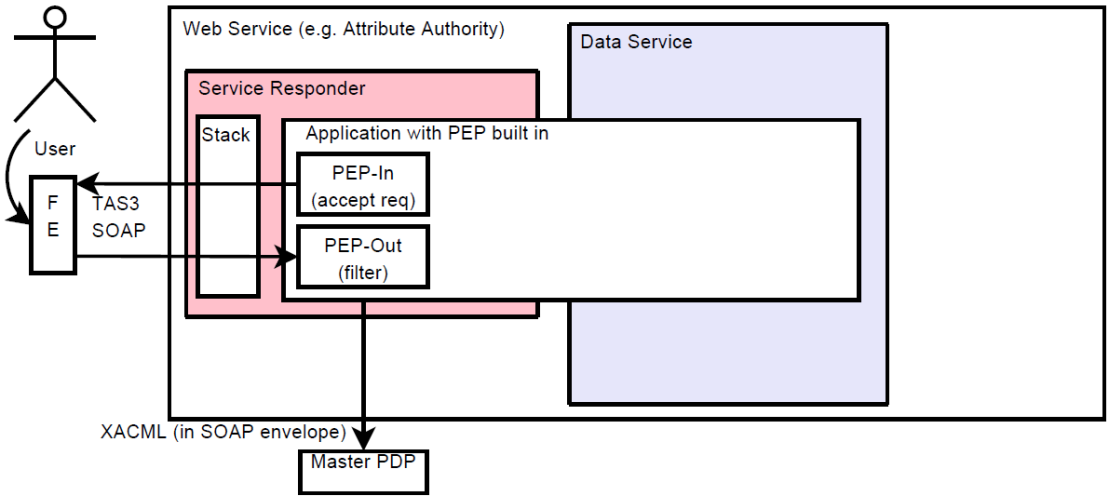


Figure 4.1: Application Integration: PEP implemented directly in application.

Conceptually the simplest solution, but in terms of new code to write probably the most costly approach, is shown in Fig-4.1. This requires the adopter to build a TAS³ compliant PEP into the legacy application. This approach has the advantage of allowing full control over the enforcement process, including the inputs to the Master PDP. The disadvantage is the learning curve to learn the TAS³ architecture in sufficient detail to implement it correctly and to get it certified.

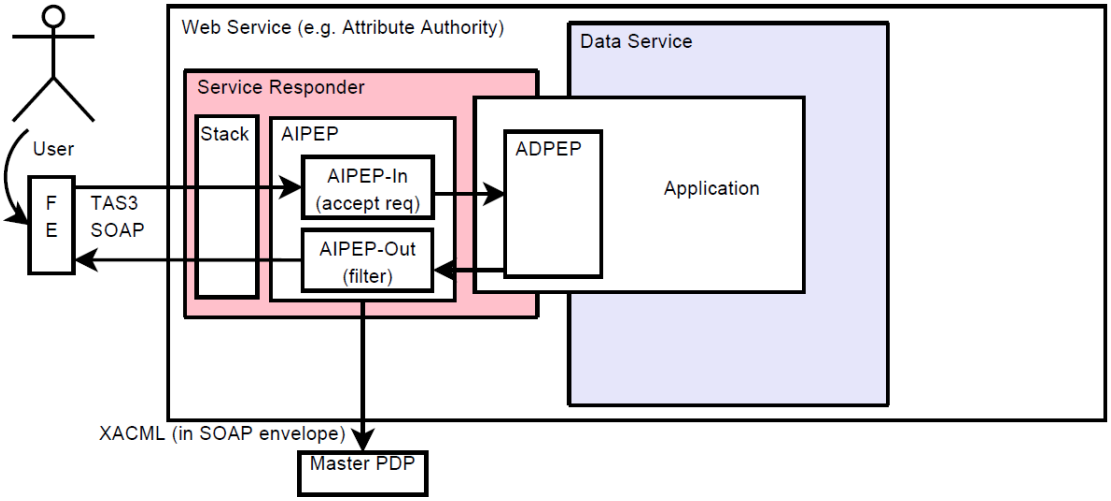


Figure 4.2: Application Integration: Simple Application Dependent PEP implemented in application itself.

Fig-4.2 depicts a slightly different strategy where the application only implements a simple Application Instance PEP (the ADPEP), which then communicates with the Application Class Dependent Application Instance Independent PEP (AIPEP) supplied by the TAS³ Project. One AIPEP needs to be developed for each application level protocol e.g. Http. However, since all TAS³ traffic is http based then we only need to provide one AIPEP. In this approach, the AIPEP component handles most of the TAS³ specific parts, as well as the application level protocol, and can be an already certified component, making compliance certification easier.

In this model the communication between the AIPEP and the ADPEP could be an application programmable interface (API) making coding of the ADPEP relatively straightforward. . In TAS³ we have chosen to use the SAML-XACML protocol as described in D7.1 for communication between the AIPEP and the authorisation infrastructure (i.e. the Master PDP in Figure 4.2).

Fig-4.3 illustrates some specific integration strategies with the intent of enabling legacy data sources that cannot be modified. In (A) the SOA Gateway evolves to support the TAS³ architecture, in (B) the SOA GW is front-ended by the WP8 database which supports the TAS³ architecture. If export of the legacy data is an option, then it may be simplest to import the data to the WP8 database and dispense with the legacy data source entirely (C).

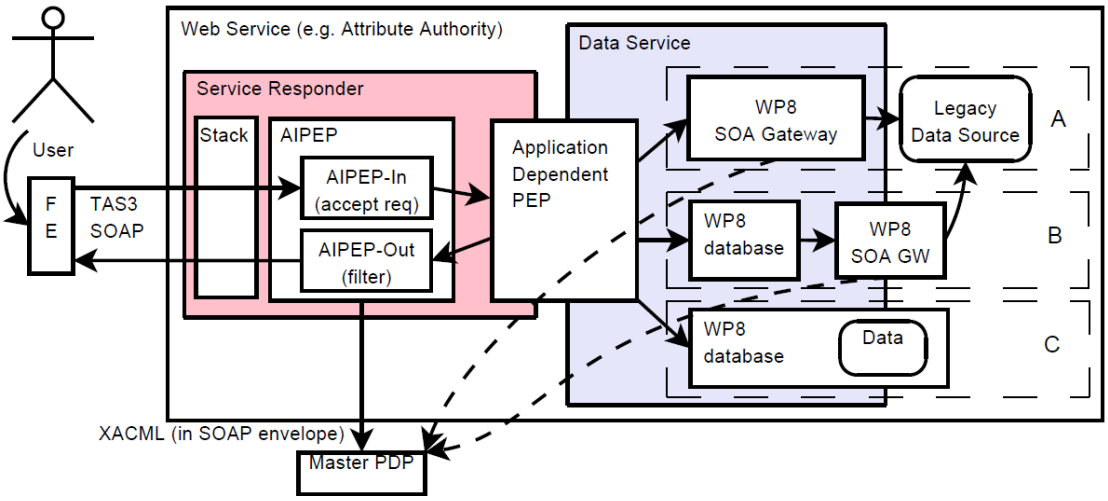


Figure 4.3: Application Integration using ADPEP and (A) SOA Gateway, (B) WP8 DB as frontend to SOA GW, (C) WP8 database.

4.3 The Application's PEP

The Application's Policy Enforcement Point (PEP) is a gateway that provides access to the TAS³ infrastructure for applications like web applications with a web frontend, business process engines, databases or repositories and many other systems, which are either requesting or responding over a TAS³ secured and trusted channel. Per section 2.2.1 (see also Fig-2.2), the PEP belongs to the Front End Services and Web Service components inside the Payload boundary. The PEP can be considered as consisting of two parts, the Application Class Dependent Application Instance Independent PEP (AIPEP) and the Application Instance Dependent PEP (ADPEP).

As described in Section 2.2.2, the PEP is divided into two different types:

1. ServiceRequester PEP: This web service is part of the Front End Services. Internally, the ServiceRequester PEP constitutes together with the Stack, the Service Requester. The Stack handles SOAP protocol details. The Application Class Dependent Application Instance Independent PEP (AI PEP) contacts the Master PDP, which contacts the different PDPs like the User PDP, Organization PDP or a Trust PDP to decide whether a request is trusted or not.

   The main task of the ADPEP is to collect all required information for an appropriate request that has to be checked by the TAS³ authorization infrastructure, give this to the AIPEP then route the request (assuming it is granted) in an appropriate way to the 'Service Application' and then give the results back to the AIPEP. Further information about the payload, which builds up the request, can be found in [TAS3D81RepoSW] figure 8. Common information about the functionalities of the ServiceRequester PEP can be found in [TAS3D81RepoSW] and in [TAS3D83CliSW].

   The next steps before sending the request are done by the 'Stack'. As mentioned before, the 'Stack' (and its main component: the AIPEP) is application instance independent. Its main task is the preparation of the

request. The message has to be signed and augmented according to web services binding. WP4, WP5 and especially WP7 work on this security related part of the service requester, whereas WP8 is responsible for the application dependent part.

2. ServiceResponder PEP: This second application dependent service, which functions as responder, is part of the Service Responder component in the Web Service boundary (see Fig-2.3). In analogy to the ServiceRequester PEP, the ServiceResponder PEP also needs the Application Instance Dependent PEP (ADPEP) and the 'Stack' (with AIPEP and its underlying PDPs) to function correctly. That means, signing and preparation of the message according to the web service binding, the policy checks and the communication with the 'Trust policy decision point', as done by the 'Stack components'.

   The main task of the ADPEP is to receive granted requests, route them in an appropriate way to the 'Service Application' and then check with the AIPEP if the results can be sent back in the response to the requester. More details about the functionalities of the ServiceResponder PEP can be found in [TAS3D81RepoSW] in chapter 3.2.

Auxiliary components in the ADPEP Service

To fulfil the mentioned functions of the ADPEP Services (Requester and Responder), some auxiliary services are required. These services belong to tasks (Task 8.3 - see DoW), which are documented in [TAS3D82BackOffice].

These services neither store person related data nor serve the user directly. They provide ontologies and metadata, perform search and aggregation operations and transform data into specific formats. The back office services are a component of the TAS³ Trusted Application Infrastructure but not of the core TAS³ Trust and Security Infrastructure.

The main Auxiliary or Back Office Services and Components are:

- The Generic Data Format ([TAS3D82BackOffice], section 2.1.2) used to store data in TAS³ repositories[1]
- Services to transform ([TAS3D82BackOffice], section 2.1) data from a custom source format to the Generic Data Format and from the Generic Data Format to a format, which is requested (and supported).
- Aggregation Service ([TAS3D82BackOffice], section 2.2) and Policy Aggregation ([TAS3D82BackOffice], chapter 8)
- Request Logger Service ([TAS3D82BackOffice], section 3.2) to store information on requests issued and responses received by TAS³ web services for auditing and maintenance purposes

1 Marc: not applicable for eHealth because of legal issues

4.4 Reputation Feedback

The workflows have a feedback collection step. This feedback is collected by a user interface and then sent to the Trust and Reputation Server by means of a web service call (e.g. SOAP). The call will contain, in addition to the feedback score, workflow context information, such as the role in which the user acts in as well as pseudonym of the user at the Trust and Reputation Service (see below). If the user is giving feedback about another user, he will know the other user's pseudonym through the business process context. This architecture allows the Trust and Reputation Server to correlate feedback from different sources without the sources having a correlation handle for the user.

The pseudonym of the user at the Trust and Reputation Server is obtained by means of normal discovery and ID mapping .

4.5 Security Enforcement for Business Processes

Business processes, when executed in a business-process-management system (BPMS), expose rich context information. This information can be used for security enforcement. Indeed, it is imperative to do so to provide tight security that adapts to situations where classical security models are too static. Furthermore, it is necessary to define security policies that take context into account. Security components specific to BPM are necessary to deal with business-process-specific context information and enforce business-process-specific security rules [SecureBPMSArch2011].

More specifically, the following security context accrues for business-process instances: (1) Activity context of calls (web-service calls or creation of human tasks), i.e. which activity in which process instance has caused the call, (2) Associated entities, which are entitites like users or external data sources associated with a process instance (either with the entire process instance, or with some element of it). (3) Execution state, for example activities waiting for execution.

Security configuration respecting such context can come in different forms, most importantly as declarative policies or simple variables. Several sources are possible. The most simplistic way is to assume default values. More flexible approaches are security policies for business-process models, which can be derived from annotations to graphical process models, and deriving settings from user interactions at run-time (e.g., a user giving his consent at run time that the business process accesses his/her personal data). When more than one policy exists, conflicts can arise. Such conflicts must be resolved; WP7 has explored respective mechanisms.

The architecture of a secure BPMS must be able to handle the security context and security configuration just described, and should should follow additional design goals. Namely it should require few changes to existing BPMS, follow standard architectures such as the XACML reference architecture and the WfMC workflow reference model, and preserve the structure of security constraints on the enforcement level in order to allow for better traceability.

The security-enforcement extensions of a BPMS (to be used in the TAS³ architecture) look as follows:

- Business process definitions are transformed so that web-service calls and requests for the creation of human tasks are sent to a policy enforcement point (PEP), augmented with the context of the call.
- For web-service calls, the PEP includes the correct token, determines the service to call (possibly from a previous service-selection step) and makes the call.
- The worklist handler (business-process client) is modified to ask for authorization whenever it allows a task to be performed.
- For human tasks, the PEP stores the context of their creation and assigns a unique ID. It adds these context to authorization queries before sending them to a PDP.
- A business-process policy information point (BP-PIP) stores context information persistently.
- Tokens acquired (e.g., through SSO by the BPMS acting as a frontend service) are stored in a special store, to be used for outgoing calls.
- A special policy decision point for business processes (PDP-BP) performs authorization decision based on security rules specific to business processes. For example, it evaluates history-based constraints such as binding of duty (BoD). The non-history-based part can be delegated to an "ordinary" PDP.
- The security configuration of a business-process instance can be changed based on user interactions. Synchronous user interactions are included into the business-process definitions, while special components provide for asynchronous user interactions.

As shown, special components are only needed for security functionality specific to business processes. They integrate with the overall TAS³ security architecture.

4.6 Business Process Registration

When user is about to start participating in a business process, he gets information about the business process policy and has to give his consent to participate in the business process. The business process policy contains a declaration about the data needs and other participants of the business process from a security and trust perspective. Such declaration is prepared from the business process model with its security and trust constraints.

Each business process model can be viewed as a high level service and can be described by a service type. This makes it possible to discover trusted (according to a trust policy) Service Providers who implement the business process.

.

5 Using Business Process Modelling to Configure the Components

This section addresses Reqs. *D1.2-3.2-ModelDrivenCfg, D1.2-3.12-SPManifest, D1.2-6.3-WhatHowWhyWho, and D1.2-6.4-Min.*

The TAS³ architecture covers a lot of functionality and some of this functionality needs to be configured carefully to match each other to ensure smooth operation from the perspective of the users, such smooth operation is perceived by users as dependability and trustworthiness, so it is a prerequisite for good public image of a Trust Network.

Correct configuration will also be essential for ensuring that services function securely. Given that most security technology is quite brittle and even minute misconfigurations lead to failure, there will be operational and commercial pressure to turn off those nonfunctional, but essential features that appear to be "causing trouble". This is an extremely dangerous slippery slope that any Trust Network MUST avoid. Liberty Alliance and SAML Interoperability and Certification programmes have clearly demonstrated this to be a real peril. Therefore it is necessary that it is possible to correctly configure the trust network such that it will work right on the first try.

Complexity of a typical Trust Network, along with all of its member systems, is of such a high degree that it is infeasible to configure it sufficiently correctly by a manual approach. Humans make mistakes. An automated, model driven configuration is the only way to create accurate and correct configuration. The corner stone is Business Process Modelling. From this model, which exists both at the top Trust Network level and at the organizational level, it should be possible to derive the following outputs:

1. Circle of Trust parameters to facilitate federation and SSO configuration, e.g., white list of roots of trust for both authentication and authorization, trusted Certificates for TLS [RFC3548] and Signing, or Metadata for entities.

2. Declarative Statements about attribute needs of the Clients involved in business processes as well as policies under which providers are willing to release attributes. This output will be a business process policy and configuration parameters of the BP specific PEP. An alternative could be [CARML] and [AAPML] files, see further [IGF], that can be used to automatically configure IGF enabled layers of Client Request PEP and Provider Request PEP.

3. Some of the top level policies that apply to the Trust Network and its members. This should facilitate configuration of the PDPs.

4. Policies, Business Process Models, and Interface Descriptions (e.g. WSDL) that are needed as input for Compliance Validation and User Information to select trusted applications, i.e. adequate business processes.

5. Business Process Models that are needed as input for Business Process Visualization, e.g., at the Dashboard.

6. Policy and business process model descriptions needed by the Configuration and security infrastructure management for business process management.

7. Contractual information behind a business process will influence the business process model itself and has an impact on the security rules, roles, and policies related to the business process.

8. Security rules that guide selection of web services and use of secure entities (data), i.e. influence the discovery service.

Security exceptions during business processes will raise an exception. Unhandled exceptions will block or break the process (go to an operator or help desk). The challenge is to handle the exceptions by explicit routines in the business process model or in some cases by using alternative paths (i.e. subprocesses) to allow the process to complete or even to look ahead and avoid exceptions before they occur by such means.

Business processes can have more complex topology than sequences of web services or just trees.

Our contribution to these requirements is to (1) descriptively specify security constraints, (2) automatically transform these constraints into enforcement level. The modelling of the processes takes place at the business level. This is the right abstraction level to define security rules relevant to the business processes and their components. Therefore a model-driven approach seems useful to allow security specifications at the business level and transform them to the execution level, e.g. to security rules for processes as role definitions and delegations or authorization rules or other ways to configure the security framework.

We provide a language that is sufficiently broad and deep to represent security constraints. It also supports security-specific user involvements, which we have identified systematically. Business Process Analysts can specify the security aspects, e.g. of a service selection, by annotation terms with few parameters.

Our language is embedded in BPMN. The BPMN 2.0 standard itself does not support security aspects. However, it provides so-called artifacts to facilitate comments within business processes. By using BPMN artifacts as containers for constraints, our approach is BPMN 2.0 standard conform at a syntax level. This follows one of our goals to architectural design, i.e. minimizing changes of existing components of business process management. We conceptually provide security annotations for the following BPMN 2.0 elements: activities, groups of activities, pools and lanes, data, events, and message flows. Additionally, we use the concept of (security) roles. Roles can be assigned to the BPMN elements pools and lanes or to activities (or group of activities). According to the BPMN standard, an activity can be a simple task or a sub-process. Our security annotations are grouped into different security categories, i.e., authorization, delegation, authentication, auditing, data and message flow security, and user interactions.

When transforming our security constraints, we have observed that there are three different kinds of targets: security policies at an abstraction level comparable to the one of XACML, adaptations of the process schema, and parameter settings for invocations of security components. Regarding realization, dedicated security components of our extended secure BPMS transform the security-enhanced business-process models into executable BPEL processes. These components assign users to tasks, enforce process-specific security policies, and manage security-relevant variables of the business process for configuration, e.g. of the PEP and PDP.

Further, also parameters to configure the trust management can be derived, e.g., places in the process where users may have the opportunity to provide feedback about the behaviour of used components thus supplying the behavioural trust management.

Additionally, we propose and provide an ontology-based approach for modelling security annotations of BPMN process diagrams. This contributes to improve usability of security modelling in supporting users, i.e. the business analysists and security designers, with a knowledge base of available annotations and its syntax and parameters.

In summary, our approach supports process designers and programmers by providing a broad range of integrated security functionality at modelling level and transforms it automatically to the execution and enforcement level.

6 Oversight and Monitoring

For a TAS³ compliant Trust Network to gain a trustworthy reputation and to ensure that belonging to the Trust Network really enables lower cost of operation through lesser fraud, improved trust, and ultimately less need for formal audits, it must take proactive and mandatory activities to monitor its activities and stop any fraudulent practices before they become a problem, ideally even before they become publicly known.

This section addresses Reqs. *D1.2-2.11-Transp, D1.2-2.12-Compr, D1.2-2.15-Resp, D1.2-2.16-Mitigate, D1.2-2.17-AuditUntamp, D1.2-2.21-DataProtLaw, D1.2-2.22-GovtAccess, D1.2-12.13-Vfy, and D1.2-12.15- Valid.*

In TAS³, the monitoring should happen at levels of

1. Continued automated, robotic, testing that compares results to both modelled expectations and past results. This is one of the focus areas of TAS³. See: On-line Compliance Testing (OCT).

2. Operations monitoring to determine uptime and performance of services, as well as detection of anomalies. Trouble ticket system for reporting and rectification of operational errors, as well as intrusion detection scans and monitoring are included here as well. Use of industry standard solutions is recommended as TAS³ does not plan additional research in this area.

3. Log audit. Some part of log audit is handled in operations monitoring, above, but logs will contain a wealth of additional information, such as usage patterns to inform new investment and areas of innovation, which can be extracted using data mining techniques. Use of industry standard solutions is encouraged in general as the only connection with TAS³ research is in the area of gathering inputs for reputation scoring.

4. Formal compliance audits should occasionally be carried out manually to ensure that the automated monitoring and audit mechanisms, above, are functioning correctly. These audits may be mandated by legislation or by governance agreement and are typically fairly costly affairs with reputable outside consultants specializing in organizational and IT audits. The TAS³ contribution for this area stems from recommendations and guidelines of the project legal team.

5. Administrative Oversight. The Trust Guarantor will take the necessary administrative steps to ensure that the Trust Network is adequately monitored, mostly automatically, but with necessary and timely manual intervention. The Trust Guarantor may, according to the Governance Agreement, be monitored by an Advisory Board, Management Board, and ultimately General Assembly.

Section of 4.3.7 "Management" of [NexofRA09] discusses the need for management interfaces in services components. TAS³ is compatible with these requirements.

6.1 Dashboard

Below we list the DASHBOARD views, features and functions for the users:

1. Portal for all connected Service Providers (including the TAS IdP) (Reqs. D1.2-9.3-SSO)

2. Accept Terms&Conditions for TAS3 (Reqs. D1.2-6.1, D1.2-6.2-Intake Process)

3. Accept Terms&Conditions for SPs (Reqs. D1.2-6.1, D1.2-6.2-Intake Process)

4. Manage and view Policy Settings (Reqs. D1.2-9.2-Policies, D1.2-9.9-Change policies, D1.2-9.10-Policy user interface)

5. Manage and view Transaction History (Reqs. D1.2-2.11-Transparancy)

6. Manage and view Data Discovery Service (Reqs. D1.2-2.3-Discovery Service)

7. Manage and view Trust Rankings (show the scorings of SPs - discover all) (Reqs. D1.2-2.11-Transp., D1.2-5.12-Trust ranking providers)

8. Manage and view the accessed data and attempts at it (Reqs. D1.2-9.5-Audit trail, D1.2-9.8-Access request, D1.2-7.28-Audit, D1.2-9.5-Trail, D1.2-9.8-UAudit)

9. Obtain legal confirmation of Views and Settings

10. Provide reputation feedback to the TAS3 system (Reqs. D1.2-5.5-Trust feedback, D1.2-6.87-Use of feedback)

11. Contact the TAS3 system administrator (email, address, faq's)

12. Information for users (individuals, providers, technicians) on TAS3

13. Manage and view the Workflow (BPE-Intalio)

14. Accept reactions from users (feed-back, complaints) (Reqs. D1.2-6.1 Intake Process, D1.2-6.9-Complaint)

15. Display Legal information (Reqs. D1.2-6.1 Intake Process)

6.2 Right of Access, Rectification, and Deletion

The data subject has the right to know what data is held about him and has the right to (request that the keeper) rectify or delete incorrect information (however, in the case of some data, such as sensitive medical or criminal data, the subject may not be allowed to read, edit or delete the data).

In online transactions it is important to be able to tell where the data originated so that the user can contact the right authority.

6.2.1 Identification of Source of Authority

The primary means of addressing the Right of Access is mandatory identification of the authority from where the data originated. TAS³ attribute authorities MUST identify themselves in the data set. One of the following approaches is acceptable:

1. If data is conveyed in SAML assertion and the origin of the data is the same as the assertion's Issuer, then the assertion's Issuer field is taken as sufficient identification of the authority.

2. If data is conveyed in an X509 attribute certificate and the origin of the data is the same as the certificate's Issuer, then the certificate's Issuer field is taken as sufficient identification of the authority.

3. Include in the data set an attribute named urn:tas3:issuer whose value is the Entity ID of the issuer.

The Right of Access, Rectification, and Deletion ultimately needs to be satisfied at the origin of the data, known as the Source of Authority. To facilitate this process, the Service Providers that are consumers or users of the data MUST display the identity of the source of any given data item or data set. Another way for the user to find out the source of the data used in transactions is to see it in the Dashboard.

Either way, the user is then expected to direct his Right of Access, Rectification, or Deletion requests directly to the Source of Authority. The user MAY request deletion of the local copy from the SP using the data, but the using SP is not responsible for correcting the data at the source. Instead the user really needs to contact the Source of Authority.

6.2.2 Facilitating Self Service Interface to Right of Access

To facilitate self service interfaces for Right of Access, Rectification, or Deletion, the data set SHOULD include the attribute urn:tas3:issuer:selfmgmt whose value is a URL to the user self management web GUI, where user MUST be able to satisfy his Right of Access, and MAY be able to satisfy Rectification and Deletion, subject to applicable authorization policies (e.g. user will not be allowed to edit his health records, only his doctor can).

6.2.3 Propagation of Rectifications by the Source of Authority

The Source of Authority MUST keep a record of the parties to which it released data. The concerned user SHOULD be able to query this record using the self service interface. The records need to be kept in the minimum for the duration specified by the trust network, but in no case for less than 6 hours.

When a data using SP requests data, it SHOULD also create a subscription to receive rectifications to the data. The Source of Authority's records MUST show if the requester created a subscription, i.e. whether it is possible to propagate rectifications to it. The Source of Authority MAY refuse data requests, or attach

short data retention obligations to the requests, from SPs that do not create subscriptions to receive rectifications.

When a user rectifies or deletes data the authority MUST check its records for SPs that have received the data and by virtue of emitted data retention obligations MAY still have copies of the data. If such party has subscribed to the changes, the authority MUST propagate the changes of the data, unless the user has given explicit instructions to the contrary.

Soliciting user's instructions on this matter is OPTIONAL. If the receiving party has not subscribed for the updates, and the user has not instructed to withhold propagation, the authority MUST log to the audit bus a notice of inability to propagate changes. The Dashboard will pick up these notices and allow the user to see them so that the user is aware of incomplete propagation.

When propagating rectifications, the receiving partyMUST further propagate, if it has given data to any further parties.

6.3 On-line Compliance Testing

This section addresses Reqs. D1.2-6.14-Compat, D1.2-6.15-MinPolicy, and D1.2-12.16-OnlineTst.

Implementation of SOA based applications result from the integration of several services. Services composing an application can change at run-time without informing all the other services integrated in the application. Furthermore, features like dynamic binding, or context-dependency prevent knowing before run-time the actual interaction among service instances.

Speaking in general terms, services are typically controlled and owned by different organizations. Thus, dealing with architectures that are not under the full control of one organization, means that the service lifecycle cannot be structured in well-defined development stages. In particular, for a (composite) service it is not clear when testing activities start or should end.

To ensure trust and dependability, the TAS³ architecture must also include adequate technology and actors to test that services within a TAS³ Trust Network behave in compliance with their expected specifications. Such testing activities must be performed on-line by special TAS³ guards, verifying that the services with a choreography actually behave as expected.

To achieve trustworthy SOA, there is the need to develop and use a methodology and tools supporting the "perpetual" (i.e. event-driven, periodically) and automatic testing of software services. The benefits with the "perpetual" and automatic testing are:

- repeatability of testing (improving the efficiency and the efficacy of the test)
- increase the quality and the trust perceived by the users of the service

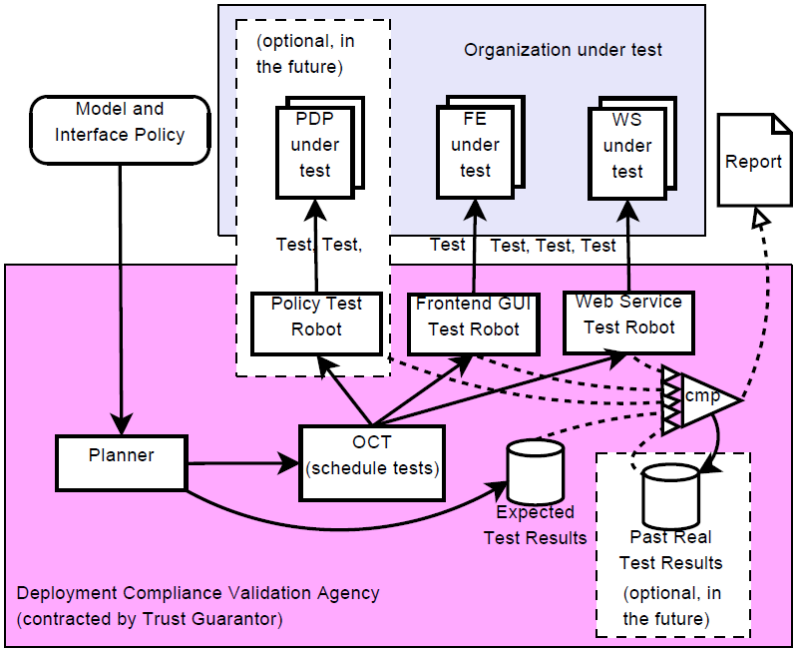


Figure 6.1: Overview of On-line Compliance Testing

The extent to which compliance is tested may vary, also depending on the registration information that should accompany services (e.g. models describing interfaces, policies, usage, etc.), which is part of the governance contract.

A minimal assumption is that services should access and perform within a TAS³ infrastructure according to an explicitly declared set of policies and that the infrastructure should not allow violation to the declared policy, or at least should recognize such violation. Testing is applied in order to reduce the risk that services within a TAS³ infrastructure will get in contact with unreliable services. Therefore services

within a TAS³ compliant infrastructure will be regularly submitted to testing sessions aiming to assess that a service does not break its policy.

As an important remark, we advise that this on-line testing approach does not prevent the execution of canonical off-line testing activities (e.g. where the service is tested by its developer trying to anticipate possible usage scenarios), rather it is an additional means to increase the trustworthiness of the TAS³ architecture.

6.3.1 Involved Actors

On-line Compliance Testing impacts on the following of actors of the TAS³ scenario.

- Ecosystem
  - Service Provider
  - Reputation Providers
  - Software Certification agencies

- Deployment certification and audit agencies
- Compliance Authority

- Components
  - Web Service (WSP)
  - IdP (Identity Provider)
  - Service Registry
  - Id Mapper
  - Linking Service
  - Organizational PDPs
  - Trust Network PDP

6.3.2 On-line Testing Process and Architecture

The TAS³ architecture includes an on-line testing infrastructure, in which, the TAS³ services are tested according to a set of published models describing specific behavioural characteristics of the service itself. In the following, the term OCT refers both to the on-line compliance testing process and to the infrastructure that implements it.

With respect to the current scope of the TAS³ architecture, the compliance testing functionality requires that each service exposes within the TAS³ choreography its public interface (i.e. its exported operations) and the public policies it will comply with (or a references to them). In particular, each service is tested on-line when it requests to be registered to a TAS³ directory service. Further on-line test sessions can be activated by the compliance testing (i.e. Trust Network level) directory service either in event-driven or periodic fashion.

Directory Services within a TAS³ architecture interact with testing components to detect services failures. The compliance testing increases trust both on the TAS³ architecture and the linked services. A software service willing to be registered to a TAS³ directory service, may also have to comply with other policies that are not publicly manifested. In this case the service will not be tested with respect to such policies since such behaviour is hidden from the external interfaces of the service.

During the on-line compliance testing process, references to the service should not be retrievable by means of the directory service. At the end of the compliance verification process, if and only if all the tests have been successfully executed, service references will be listed by the directory service.

During the on-line testing, the OCT activates tester robots. Each tester invokes the service under test simulating service requests with identity credentials taken from a pre-packed identity test suite. The tester robot collects the service reply (i.e. either a response message, or a deny access), and compares it with the expected results: a difference between the service reply and the expected result reveals a mismatch between how the service policy is manifested and how the policy is implemented within the service.

Note that the TAS³ architecture has a precise requirement that error messages returned after a request for a resource (e.g. "access denied" message) must be identifiable as such. Applications might masquerade error messages for user-friendliness (e.g. they could produce a "pretty formatted" page); nonetheless, the TAS³ architecture needs to be able to unambiguously recognize error messages without the need to delve into the semantics of the payload of the message. This is accomplished by each application declaring to the on-line compliance testing infrastructure at least one successful and one failing test case with exact description of what the messages look like and what are the relevant parts.

In real life scenarios, a service under testmay need to access external services when invoked by the tester robot. Indeed, in some cases a testing interaction between the service under test and externally invoked service may have permanent effects (e.g. on a stateful resource). Let's consider that the service under test queries the directory service to lookup a relevant end point. In this case, OCT should consider that the registry may return a reference to a Proxy version of the required service: this service will implement the same interface as the required service. Doing so, the real implementation of registered services is hidden to those services waiting for compliance validation - a useful feature while project is ongoing and full service is yet unavailable.

In such cases, the directory service and OCT have to be able to link to an existing service proxy or to generate new ones. Obviously this will increase the complexity of the framework and asks for the provisioning of service description models suitable for automatic generation of service stubs.

Fig-6.2 depicts a UML Diagram describing the components of the On-line Compliance Testing framework. In the following we list a detailed descriptions of each component:

- Compliance Validator Discovery Service: according to the architecture given in Fig-6.2, this component enhances the functionality provided by the Discovery Service. In particular, the Compliance Validator Discovery Service is a Discovery Service able to apply the compliance validation at runtime. The Compliance Validator Discovery Service aggregates three sub-components: the Compliance Validator, the Proxy Factory and the Pending Services DB.
- Compliance Validator : this component activates the testing session when a service makes a request for being included in a TAS³ infrastructure. The testing session will result in a sequence of invocations to the services requesting to be registered. In case the testing session does not highlight any error the service will be registered otherwise the request will be rejected.
- Tester Robot: this is the component that actually runs the test on a given service. In particular, the Compliance Validator activates the Tester Robot passing to it a reference to the service that needs to be tested and to the corresponding test suites to use.
- Request Generator: this component defines which is the next invocation to make to the service under test in order to assess its correctness;

- Test Checker: this is the component that checks that the replies of the service under test actually conform to what is specified;
- Test Attribute Generator: this component defines which attribute values are to be used in the testing invocations.
- Front Channel Tester: this component extends the Tester Robot adding to the tester component specific features to interact with the front channel of a service application in TAS³. Since this component is a Tester Robot, it has all the features that a Tester Robot has, including the relationship with the other components (e.g. Request Generator, Test Checker, Test Attribute Generator).
- Back Channel Tester: this component extends the Tester Robot adding to the tester component specific features to interact with the back channel of a service application in TAS³. Since this component is a Tester Robot, it has all the features that a Tester Robot has, including the relationship with the other components (e.g. Request Generator, Test Checker, Test Attribute Generator).
- DB of Roles as Signed Test Response: this DB contains the identity test suite that the tester can use to test other services simulating a different identity.
- DB Test Report: in this DB the compliance validator logs the result of a testing session and the possible failures highlighted.
- Proxy Factory: this component automatically generates proxy services to simulate already registered services.
- Pending Services DB: this DB will contain the identities of services that requested to enter a TAS³ infrastructure precinct but still did not pass the testing session. Services in such DB are not returned as result of a discovery request. Identities are removed from this DB when the corresponding testing session is terminated.

Note that, each entity (i.e. components or artifacts) in the diagram, has a role with respect to the domain organization. Specifically, according to the general architecture depicted in Fig-2.2:

- The artifacts Public Iterface, and Public Policy, are entities within theModelling&Configuration Management area,
- The OCT components (Compliance Validator Discovery Service, Compliance Validator, Tester Robot, Request Generator, Test Checker, Test Attribute Generator, Front ChannelTester, Back Channel Tester, DB of Roles, DB Test Report, Proxy Factory, and Pending Services DB) are entities within the Audit & Monitor area,
- The components IDP, Discovery Service, and Web Service, are entities within the Runtime & Enforcement area.

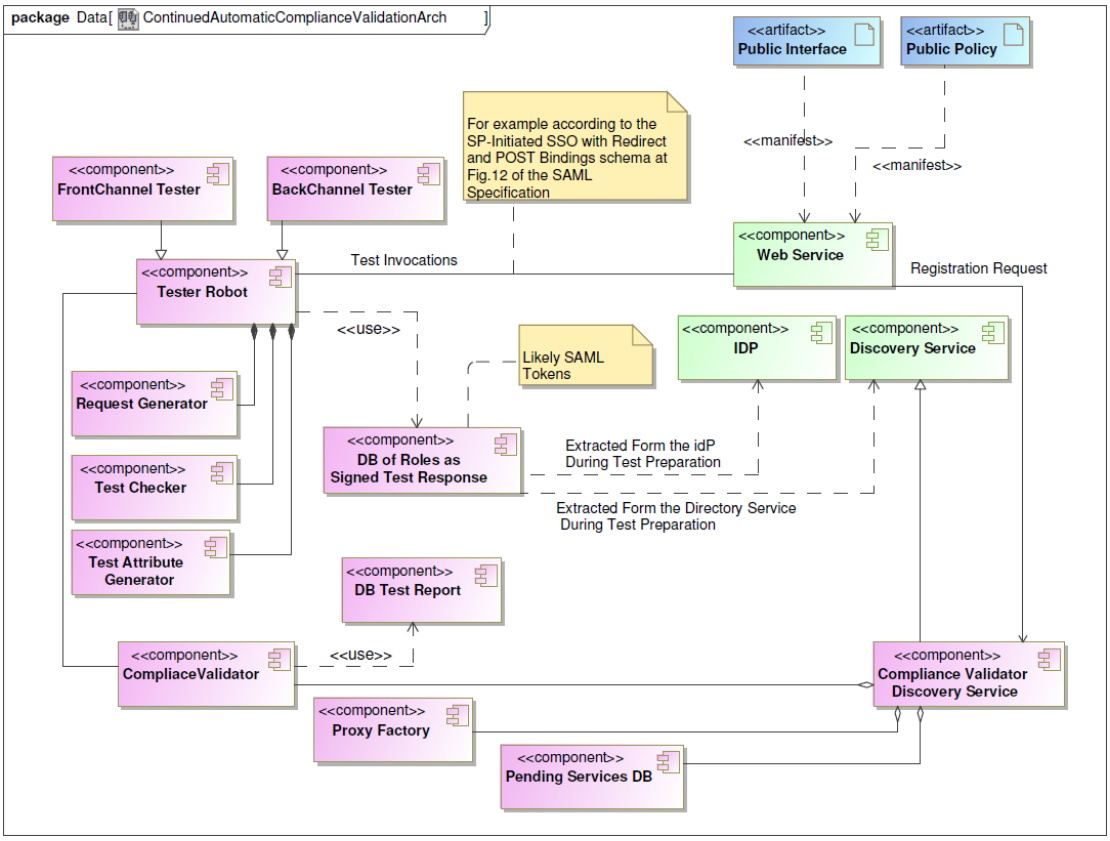


Figure 6.2: UML Component Diagram of the On-line Compliance Testing (OCT).

6.4 Operations Monitoring and Intrusion Detection

[NexofRA09], section 4.3.7 "Management", paragraph 4, highlights the need for operational monitoring. While such monitoring is not a requirement for technical interoperability of the TAS³ framework, it will be necessary to maintain the reputation of TAS³ Service Providers and/or Trust Guarantor. This topic, which addresses Req. D1.2-1.6, is not an area for TAS³ research work. Consequently:

1. Standard operations monitoring approaches such as SNMP [RFC1157] and Nagios [Nagios] SHOULD be implemented.

2. Each organization in the Trust Network MUST be protected by network level firewall or packet filter. Any deny events from the firewall SHOULD be fed to the Intrusion Detection Channel of the Audit Event Bus.

3. Each organization in the Trust Network SHOULD operate an Intrusion Detection System (IDS) to

   a. Detect well known attacks (e.g. ping of death)

   b. Port scanning

   c. Abusive patterns of usage

Any suspicious events from the IDS SHOULD be fed to the Intrusion Detection Channel of the Audit Event Bus.

6.5 Log Audit

This section addresses Reqs. *D1.2-2.17-AuditUntamp, D1.2-3.3-Dash, D1.2-6.10-Redress, and D1.2-7.21-Safe.*

Log audit has several goals

1. In case of attempted repudiation, prove that events happened
2. For investigation, browse and visualize events so that a human investigator can get a relevant and sufficient overview.
3. On an ongoing basis automatically detect noncompliant events
4. On an ongoing basis ensure that the systems are functioning correctly
5. Provide statistics about users and their behaviour
6. Provide statistics about system use and behaviour
7. Provide baseline of information that allows trust, security, and access control mechanisms to be cross checked

Log audit raises several issues

A. Collection

B. Distribution

C. Privacy

D. Retention

E. Falsification

F. Omission

G. Denial of Service and overwhelming the logging system

The log audit could also be used for billing in some circumstances, but in general we recommend that billing systems be built separately so that they can be cross checked against the logging to detect errors.

A taxonomy of audit events is presented in Annex A "Enumeration of Audit Events".

Some design requirements for Audit Log Files are discussed in [TAS3D42Repo]. Further requirements include

I. Append mode of access: Only append mode of access should be allowed, so that users or applications cannot rewind an audit log file and delete or modify information that has already been stored there

II. Authorised writing: Only authorised parties should be able to append log records to the audit trail. Though unauthorised applications or attackers

may gain access to the audit trail and try to append fake log records to the audit trail, or modify or remove the audit trail, this should be detected by the tamper detection mechanism.

III. Timestamps: Every record in the audit trail should be timestamped to provide a trusted record of when the audit data was received. We note that if the audit service is trusted to record the audit data without tampering with it, then it should also be trusted to append the correct time to the data. Therefore we do not require a secure time stamping service.

IV. Secure communication: if the audit service operates as a web service then there should be secure communications between the clients and the server in order to ensure tamper resistance, data integrity and authorised connection.

V. Secure storage on untrusted media: Since an audit trail may be viewed on untrusted machines, the security mechanisms should ensure persistent and resilient storage of the audit trail, and ensure detection of tampering of the audit trail - modification, deletion, insertion, truncation, or replacement. If tampering is detected, the audit service should be able to notify the security auditor.

VI. Support multiple simultaneous clients: The audit service should be easily and conveniently accessible and it should be able to serve multiple client applications simultaneously.

VII. Logging efficiency: The computational work and the storage size required by the audit service should be as efficient as possible.

VIII. Contents transparency: the audit service should be able to record any digital content coming from any service.

IX. Authorised reading: Since the audit trail may contain personal or sensitive information, then the audit service should ensure that only authorised applications or people have the privilege to read the audit trail. The audit trail may be encrypted to further protect confidentiality.

6.5.1 Log Collection and Storage

This section addresses Req. *D1.2-2.22-GovtAccess*.

In the TAS³ architecture the audit trail is collected and stored locally primarily at the system entities, such as SPs, IdPs, the IM, and the like or near them in the organizations that operate these entities. Everyone that collects a log is bound by a Governance Agreement so that responsible behaviour can be enforced when technical solutions fall short in some area of protection.

The log events originate in various components at various times, see Annex A "Enumeration of Audit Events" for an idea of the types of events that will be generated. For example, Web Services Stack component will check signatures on the tokens (assertions) that are presented and log both positive and negative outcomes.

The system entities that collect the audit trail or the centralized audit function of the organization report the events in *summary form*, containing *pointers* to the actual audit records, to the Audit Event Bus. Each component may keep its local log in its own format (in future we may provide a standard format), but the summary logging to the Audit Event Bus will follow the TAS³ standard format. To facilitate standard format summary logging, TAS³ may provide a reusable software library.

The Audit Event Bus is divided into channels to which different events are broadcast. This allows minimal exposure as subscriptions can be on the basis of only relevant events. The subscriptions can also be controlled such that only authorized parties with "need to know" can see certain types of events (see req IX above).

The Audit Event Bus is potentially implemented as part of a more generic Event Bus infrastructure, but due to special privacy and security requirements, Audit Events MUST NOT be mixed with other business messages, unless in encrypted form. If the generic event bus supports an encrypted private channel, a VPN if you like, then sharing of the infrastructure may be possible.

The Audit Bus infrastructure MUST be free of conflicts of interest. In particular, it should not be operated by one of the SPs. In case the Event Bus sharing is implemented, then the operator of the shared infrastructure MUST be free of conflict of interest as well.

6.5.2 Privacy Issues: What to Collect and What to Report

This satisfies Req. *D1.2-4.2-BPPrivacy*.

The main issues are

1. Avoid logging anything to the summary audit trail that could become a correlation handle

2. Avoid logging PII to the summary audit trail unless absolutely necessary

Generally a lot of detail will be logged locally. This will include the tokens used in identification of the user, usually in pseudonymous form as well as the PII handled by the Service Provider. This detail tends to be necessary to legally protect the Service Provider. TAS³ does not restrict what information SPs can log locally.

6.6 Administrative Oversight

This section partially addresses Req. *D1.2-6.10-Redress*.

Administrative oversight and stake holder issues are covered in [TAS3BIZ].

7 Conclusion: TAS³ is Secure and Trustworthy

The comprehensive approach of the TAS³ architecture and framework achieves real and tangible overall security and trustworthiness gains when compared with state of the art for multiplayer networks of comparable size. The TAS³ features that contribute to this are

1. Legal concerns are built-in from the ground up
2. A comprehensive and strong digitally signed audit trail
3. A conditionally pseudonymous audit trail to guarantee the privacy of Users who play by the rules, while allowing abuse to be exposed through collaboration of Service Providers.
4. A fully pseudonymous design at all layers to protect user privacy
5. Fully encrypted and digitally signed messages using strong algorithms
6. Based on state-of-the-art Single Sign-On protocol standard (SAML 2.0) which has had extensive security review
   - Extensive security review and scrutiny already done
   - Multiple commercial and open source implementations that are mature.
   - Certification program for implementations further ensures quality
7. Based on state-of-the-art Identity Web Service Protocol standards (ID-WSF 2.0) which have had extensive security review
   - Extensive security review and scrutiny already done
   - Multiple commercial and open source implementations
   - Certification program for implementations further ensures quality
8. Enhanced authorization infrastructure which significantly improves upon the current XACMLv2 standard
   - Extensive security review and scrutiny already done
   - Multiple commercial and open source implementations
9. Ability to use risk control and reputation
10. Use of ontologies to ensure consistent interpretation of data and authorization rules
11. On-line Compliance Testing for early detection of discrepancies and problems
12. Business Process Modelling driven configuration to ensure consistently correct configuration

13. TAS³ has performed a systematic threat and risk analysis (see Annex B) to ensure that the architecture addresses the widest possible range of security and privacy threats.

14. Software engineering techniques used by the project to consistently achieve high quality and absence of security bugs in the software components that are TAS³ deliverables.

The TAS³ Architecture is novel as a blueprint that brings together identity management, attribute based access control, business process modelling, and dynamic trust. The architecture acts as an interoperability profile for various standards based protocols covering these areas. Other areas of innovation are user transparency features like the Dashboard, user accessible audit trail, and automated compliance validation; privacy protection using sticky policies; marriage of trust and privacy Negotiation with discovery and trust scoring; secure dynamic business processes; and built-in first class support for delegation.

Annex A: Enumeration of Audit Events

To understand the wealth of audit trail data we start by enumerating them all:

1. Session Events Channel:
    a. Session creation (possibly even an anonymous session)
    b. Session upgrade (e.g. SSO on an anonymous session, step-up auth)
    c. Session refresh
    d. Session termination
    e. Session expiry
    f. Session revival (if appropriate, could be used as a factor in authentication)
2. User Authentication Events Channel:
    a. Positive
    b. Failure with Retry
    c. Definitive Failure
3. Token Issuing Channel:
    a. Tokens issued with:
        i. Issuer
        ii. Subject
        iii. Audience
        iv. Policy constraints
        v. Validity time and/or usage count
        vi. General content of the token
    b. Token validation at relying party
    c. Token use, to the appropriate extent
    d. Token revocation when applicable
4. Authorization Channel:
    a. Az request parameters
    b. Az decision returned
    c. Obligations

5. Service Requester Channel:
    a. Choice of Service Provider
        i. Discovery
        ii. Hardwired choice of Service
        iii. Automated or algorithmic Choice of Service
        iv. Choice of Service solicited from the User
    b. Trust negotiation steps
    c. Consent to send data, consent points, how was the answer obtained (e.g. automatic vs. interaction)
    d. Service Call event
        i. Signature preparation, including choice of signing key
        ii. Log of content of the message
        iii. Peer authentication
        iv. Success or failure to send message
    e. Service Call exception
        i. Redirect or end point change
        ii. Recredentialing
        iii. Interaction requested
        iv. Replay after interaction
        v. Dry-run
    f. Service Call Response
        i. Log of content of the message
        ii. Peer authentication (usually by Request-Response pattern)
        iii. Success or failure to receive message
    g. Service Call Response exception
        i. Failures, as detailed on the Faults Channel
        ii. Application layer success or failure
    h. Obligations processing
        i. Presence of obligation

ii. Specific processing steps

iii. Failure to process obligation

6. Service Responder Channel:
   a. Trust establishment and trust negotiation steps
   b. Request Acceptance
   c. Response filtering and authorization decision
   d. Attachment of obligations
2. PII Collection Channel
3. PII Release Channel
4. User Registration Channel:
   a. Register
   b. Modify
   c. Deregister
5. SP Registration Channel:
   a. Register
   b. Modify
   c. Change of Control
   d. Deregister
6. User Reputation Channel:
   a. Explicit complaint or praise
   b. Other events that affect reputation
7. Service Reputation Channel:
   a. Explicit complaint or praise
   b. Other events that affect reputation
8. Browsing Event Channel (usually not shared)
9. Faults Channel:
   a. Malformed protocol message
   b. Insufficient sec mech

c. Signature verification fault
    i. Malformed
    ii. Crypto (public key or hash)
    iii. Certificate validity (missing CA trust chain)
d. Inappropriate use
    i. Audience
    ii. Constraints
e. Expired tokens
f. Replay of message or token
g. Unsolicited message
h. Missing database entry
i. Explicit fault report

10. DoS Channel:
    a. Invocation frequency alert
    b. Data volume alert
    c. Explicit DoS report (e.g. from monitoring organizations)
11. Intrusion Detection System and Firewall ACL Channel:
    a. Scan alert
    b. Attack fingerprint alert
    c. Firewall deny rule triggered
12. Operations monitoring Channel:
    a. Server / Service
        i. Up
        ii. Down
        iii. Scheduled downtime
        iv. Congested
        v. Retry
        vi. Fail Over

13. Audit Operation Channel (very restricted circulation):
    a. Undertaking audits
    b. Outcomes of audit
14. Billing Event Channel
15. Customer Care Event Channel

Annex B: TAS³ Risk Assessment

B.1 Executive Summary

Threat modelling aims at studying the potential problems and attacks against a system in order to document how attacks are mitigated. In this document, we analyze threats and suggest solutions in order to produce internal threat analysis document. It provides an assessment on how threats are mitigated and which threats are remaining. It only provides the threat model of components developed in this research project. TAS³ is an integration project with the vision of implementing an architecture. Such an architecture-driven approach means to use a methodology where the assessment can be done by component.

The document contains a brief overview of some existing methods, the description of the methodology adopted (derived from the NIST800-30 Microsoft methodology) and the risk assessment by components.

In the deliverable D2.1, the TAS³ Architecture has already presented some inputs in this direction (Annex B that summarizes the threats that the TAS³ architecture is designed to protect against).

B.2 Introduction

This section provides a brief overview over some of the existing methods and standards related to risk analysis. It concludes by identifying some issues that to little degree are covered by the current state of the art. Most of the existing methods have been presented in [?].

B.3 Risk Analysis Methods

B.3.1 OCTAVE (Operationally Critical Threat, Asset, and Vulnerability Evaluation)

OCTAVE [Alberts01] is a general approach for evaluating and managing information security risks. As information security includes issues related to both business and technology, an inter-disciplinary analysis team that includes people from both the business units and the IT department performs the evaluation. The evaluation is performed in three phases:

Phase 1 Build Asset-Based Threat Profiles. The analysis team identifies what is important to the organization, i.e. what are the information-related assets of the organization, and reviews what is currently being done to protect those assets. The analysis team also selects the critical assets that are most important to the organization. The team then describes security requirements for the critical assets and identifies threats to the critical assets.

Phase 2 Identify Infrastructure Vulnerabilities. The team evaluates the information in-frastructure and identifies key information technology systems and components re-lated to each critical asset. Key components are

examined for weaknesses (technol-ogy vulnerabilities) that can lead to unauthorized action against critical assets.

Phase 3 Develop Security Strategy and Plans. The analysis team identifies risks to the organization's critical assets and decides what to do about them. The team cre-ates a protection strategy for the organization and mitigation plans to address the risks to the critical assets, based upon an analysis of the information gathered.

OCTAVE provides a snapshot analysis at a given point in time. Therefore, OCTAVE advises that the organization either performs new evaluations periodically or triggered by major events, such as corporate reorganization or redesign of the computing infrastructure. OCTAVE comes with predefined templates for documenting information during the analysis.

B.3.2 CRAMM

CRAMM (CCTA Risk Analysis and Management Method [Siemens10]) provides a stepwise and disciplined risk analysis method that takes both technical and non-technical (e.g. physical and human) aspects of security into account. In its original form, it was adopted as a standard by the U.K. government organization CCTA (Central Computer and Telecommunications Agency). Similarly to OCTAVE, CRAMM defines three stages of analysis:

Stage 1 Asset identification and valuation. The reviewer identifies the physical (e.g. IT hardware), software (e.g. application packages), data (e.g. the information held on the IT system) and location assets that make up the information system. Value is assigned to assets.

Stage 2 Threat and vulnerability assessment. The likelihood of potential problems are identified, taking into consideration both accidental and deliberate threats, such as hacking, viruses, equipment or software failure, wilful damage or terrorism, and errors made by people. Based on this, the risk level is calculated.

Stage 3 Countermeasure selection and recommendation. The measure of risk is evaluated in order to decide what countermeasures should be implemented. CRAMM provides a countermeasure library where a threshold level is associated with the countermeasures, thereby providing aid in the decision whether to implement a given countermeasure.

During a CRAMM analysis, the reviewer gathers information by interviewing the asset owners, system users, technical support staff and security manager. A standardized CRAMM format is used for documenting results, mostly in the form of specialized tables.

B.3.3 Microsoft's Security Risk Management

Microsoft has developed their own risk guideline [Microsoft06]. This guideline defines the Microsoft Security Risk Management Process, which has four primary phases:

Phase 1 Assessing risk. Data are gathered in order to identify risks to the business, and to prioritize between the risks.

Phase 2 Conducting decision support. Functional requirements to mitigate risks are defined. Control solutions (treatments) are identified and evaluated, and a cost-benefit analysis is performed.

Phase 3 Implementing controls. The chosen control solutions are implemented and deployed.

Phase 4 Measuring program effectiveness. The risk management process is analyzed for effectiveness, and an evaluation of whether the controls provide the expected degree of protection is performed.

As risk management is viewed as an ongoing process, these phases constitutes the parts of a risk management cycle. The guideline also goes further than defining this cycle. For example, it provides lists of common assets, threats and vulnerabilities. However, these are not intended to be comprehensive, and analysts are encouraged to add or delete items as necessary.

For example, the risk management guide for IT systems (NIST800-30) [NIST-SP800-30]. defines a methodology to assess risks while developing an application.

B.3.4 CORAS

CORAS [BraberEA07] is a method for conducting security risk analysis. CORAS provides a customized graphical language for threat and risk modelling, and comes with de-tailed guidelines explaining how the language should be used to capture and model relevant information during the various stages of the security analysis. In this respect CORAS is model-based. Special CORAS diagrams are used for documenting intermediate results, and for presenting the overall conclusions. The CORAS language is supported by a structured semantics translating CORAS diagrams into natural language (English) sentences [DahlEA07]. Following the CORAS method, a security risk analysis is conducted in seven steps:

Step 1 The first step involves an introductory meeting. The main item on the agenda for this meeting is to get the representatives of the client to present their overall goals of the analysis and the target they wish to have analyzed. Hence, during the initial step the analysts will gather information based on the client's presentations and discussions.

Step 2 The second step also involves a separate meeting with representatives of the client. However, this time the analysts will present their understanding of what they learned at the first meeting and from studying documentation that has been made available to them by the client. The second step also involves a rough, high-level security analysis. During this analysis the first threats, vulnerabilities, threat scenarios and unwanted incidents are identified. They will be used to help with directing and scoping the more detailed analysis still to come.

Step 3 The third step involves a more refined description of the target to be analysed, and also all assumptions and other preconditions being made. Step three is terminated once all this documentation has been approved by the client.

Step 4 This step is organised as a workshop, drawn from people with expertise on the target of the analysis. The goal is to identify as many potential unwanted incidents as possible, as well as threats, vulnerabilities and threat scenarios.

Step 5 The fifth step is also organised as a workshop. This time the focus is on estimating consequences and likelihood values for each of the identified unwanted inci-dents.

Step 6 This step involves giving the client the first overall risk picture. This will typically trigger some adjustments and corrections.

Step 7 The last step is devoted to treatment identification, as well as addressing cost/benefit issues of the treatments. This step is best organized as a workshop.

The terminology of CORAS is to a large degree taken from the standard (Standars Australia / Standars New Zealand 2004). Therefore, the conceptual foundation is to a large degree in accordance to this standard.

B.3.5 ISO/IEC 27001 (BS7799-2:2002)

ISO 27001 is a standard [ISO27001]. The risk assessment concerns a generic requirement that risk assessment has to be made through a recognized method but no support is provided.

The Risk treatment is a generic recommendation that risk treatment has to be made.

The risk acceptance concerns an indirectly implied through "statement of applicability".

This standard is dedicated to a process of certification. It enables the comparison of an information security management system through a series of controls. This standard does not cover risk analysis or certification of the Risk Management. Of UK origin, this standard has been adopted by ISO with some modifications. A certificate granted according to this standard confirms the compliance of an organization with defined requirements to information security management and a set of security controls.

B.4 Our methodology

Here are some advantages/disadvantages of each of the methods described above:

OCTAVE is a self-directed approach, meaning that people from an organization assume responsibility for setting the organization's security strategy. OCTAVES is a variation of the approach tailored to the limited means and unique constraints typically found in small organizations (less than 100 people). OCTAVE is led by a small, interdisciplinary team (three to five people) of an organization's personnel who gather

and analyze information, producing a protection strategy and mitigation plans based on the organization's unique operational security risks. To conduct OCTAVE effectively, the team must have broad knowledge of the organization's business and security processes, so it will be able to conduct all activities by itself.

CRAMM is a risk analysis method developed by the British government organization CCTA (Central Communication and Telecommunication Agency), now renamed the Office of Government Commerce (OGC). A tool having the same name supports the method: CRAMM. The CRAMM method is rather difficult to use without the CRAMM tool. The first releases of CRAMM (method and tool) were based on best practices of British government organizations. At present CRAMMis the UK government's preferred risk analysis method, but CRAMM is also used in many countries outside the UK. CRAMM is especially appropriate for large organizations, like government bodies and industry.

Special Publication 800-series report gives very detailed guidance and identification of what should be considered within a Risk Management and Risk Assessment in computer security. There are some detailed checklists, graphics (including flowchart) and mathematical formulas, as well as references that are mainly based on US regulatory issues.

The main innovations of the CORAS project stem from its emphasis on integrating risk analysis tightly into a UML and RM-ODP setting, supported by an iterative process, and underpinned by a platform for tool-integration targeting openness and interoperability.

The standard **ISO/IEC 27001** (BS7799-2:2002) does not cover risk analysis or certification of the Risk Management.

What we need is a directed and detailed approach and NIST800-30 answers in big part to this. To evaluate the threat against TAS³ components, a methodology based on the book "Threat Modeling" [SwiderskiSnyder04] has been chosen. This threat modeling is quite similar to NIST800-30 but proposes deeper analysis that can be directly integrated with software development tool enabling threat modelling from design to test. Even if both approaches would be suitable, the latter has been chosen for pragmatic reasons: a European project already worked successfully with this methodology (the Mosquito Project). Then, to fulfill specificities of collaborative research projects, we slightly changed the approach. Indeed, threat modeling is generally used to study threats against an application or a system and to verify that common threat are correctly handled and mitigated. In TAS³, we focus on the threat model of the TAS³ components and are thus confronted to uncommon threats and mitigations.

B.5 Risk Assessment Methodology

The following methodology is used in this document:

i. Identify Components

j. Identify sub components and entry points

k. Identify Assets

l. Identify Threat

m. Identify Attacks

n. Identify Mitigation

For each of the last four sections, we propose a list of possible choices. These choices are just given as examples, they may not cover the entire spectrum of threats, attacks, or mitigation.

B.5.1 Identify the Components[2]

The threat model is defined component by component since components can be reused in different applications and to let project partner work on their own component(s) in parallel.

Here is the list of TAS³ components:

1. T3-ACVS: Authorization Credential Validation Service
2. T3-BP-CLIENT: Business Process User Interface
3. T3-BP-DEL: Business Process Delegation Service
4. T3-BP-ENGINE-ODE: Apache ODE Business Process Execution Engine
5. T3-BP-MGR: Business Process Administration Interface
6. T3-BP-PEP: Business Process Policy Enforcement Point
7. T3-BP-PIP: Business Process Policy Information Point
8. T3-BP-SMC: Business Process Security Configuration Component
9. T3-BUS-AUD: Audit Event Bus
10. T3-DEL: Delegation Service
11. T3-IDB-ACSIS
12. T3-IDP-SHIB: Shibboleth IDP
13. T3-IDP-SHIB-AGG: Enhancement to Shibboleth IDP to support attribute aggregation
14. T3-LOG-SAWS: Secure Auditing Web Service
15. T3-LOG-WRAP-SAWS: Wrapper Web service around SAWS with extensions
16. T3-OCT: Online Compliance Testing

[2] This section may need to be updated in September once the final components for the pilots are finished.

17. T3-OCT-PLANNER: Test Planner fo the Online Compliance Testing
18. T3-ONT-SER: Ontology Server
19. T3-PDP-BP: Business Process Policy Decision Point
20. T3-PDP-BTG: Break the Glass PDP
21. T3-PDP-M: Policy Decision Point/Master PDP
22. T3-PDP-P: PERMIS PDP
23. T3-PDP-T: Trust Policy Decision Point
24. T3-PEP-AI: Application-independent Policy Enforcement Point
25. T3-POL-GUI: Graphical Policy Editor
26. T3-POL-CNL: Controlled Natural Language Policy Editor
27. T3-POL-WIZ: Wizard Policy Editor
28. T3-PORT-JBOSS: JBOSS portal framework
29. T3-REP-FEDORA: TAS³ reference repository
30. T3-REP-JFEDORA: JFEDORA Library for TAS³ Generic Data Format
31. T3-SG-BASE: SOA Gateway Base System
32. T3-SG-WSP: SOA Gateway Web Service Provider
33. T3-SP-CVT: Europass CV Transcoding Web Service
34. T3-SP-MATCHER: Job Profile Matching Service
35. T3-STACK and T3-SSO-ZXID
36. T3-TPN-TB2: Trust Negotiation Module
37. T3-TRU-CTM: Credential based trust service
38. T3-TRU-KPI: Key Performance Indicators
39. T3-TRU-RTM: Reputation Trust Management Service
40. T3-ZXID-LINUX-X86: ZXID library and tools for TAS³ in apache, Java, PHP, and C
41. ZXID-SRC: Sources for the ZXID package

B.5.2 Identify the Sub Component

Each component offers different entry points, i.e. borderlines between the component and the external world that may be under attack. We distinguish two

types of entry points: "intended" entry points, i.e. entry point that are visible to other trust domains (WS-Trust interface, etc.) and "internal" entry points that are not directly related to the TAS³ framework (http-level attacks, direct DB access, getting access to OS key store, etc.).

B.5.3 Identify the assets

Each component has assets, i.e. valuable pieces of information or functionalities that have to be protected against attackers. We can distinguish between functional assets, i.e. assets related to the application itself (e.g. medical data in e-health service), and non-functional assets, i.e. assets related to the TAS³ framework itself. This document focuses on the TAS³ components and mainly describes non functional assets. This is not covered by traditional approaches.

B.5.4 Indentify the Threats

A threat is a high-level description explaining what can go wrong (e.g. personal data disclosed, critical data destroyed). It is not directly related to the technology used to implement the component.

1. Auditing and Logging
   - User denies performing an operation
   - Attackers exploit an application without leaving a trace
   - Attackers cover their tracks
2. Authentication
   - Network eavesdropping
   - Brute force attacks
   - Dictionary attacks
   - Cookie replay attacks
   - Credential theft
3. Authorization
   - Elevation of privilege
   - Disclosure of confidential data
   - Data tampering
   - Luring attacks
4. Configuration Management
   - Unauthorized access to administration interfaces
   - Unauthorized access to configuration stores
   - Retrieval of plaintext configuration secrets
   - Lack of individual accountability
   - Over-privileged process and service accounts
5. Cryptography

- Poor key generation or key management
- Weak or custom encryption
- Checksum spoofing

6. Exception Management
   - Attacker reveals implementation details
   - Denial of service
   - Sensitive Data
   - Access to sensitive data in storage
   - Network eavesdropping
   - Data tampering
7. Input / Data Validation
   - Buffer overflows
   - Cross-site scripting
   - SQL injection
   - Canonicalization
   - Query string manipulation
   - Form field manipulation
   - Cookie manipulation
   - HTTP header manipulation
8. Session Management
   - Session hijacking
   - Session replay
   - Man in the middle

B.5.5 Identify the Attacks

An attack is a concrete way to make a threat real (e.g. attacker gets access to personal databy). Attacks can be related to the technology used to implement the component. Here some examples of potential attacks.

- Buffer Overflow Attack
- Canonicalization Attack
- Chosen Plaintext Attack
- Cross Site Scripting Attack
- Denial of Service Attack
- Forceful Browsing Attack
- Format String Attack
- HTTP Replay Attack

- Integer Overflow Attack
- LDAP Injection Attack
- Man in the Middle Attack
- Network Eavesdropping Attack
- One-click Attack
- Credentials Brute Force Attack
- Password Dictionary Attack
- Repudiation Attack
- Response Splitting Attack
- Server-side Code Injection Attack
- Session Hijacking Attack
- SQL Injection Attack
- XML Injection Attack

B.5.6 Identify the mitigation

Mitigation is a mechanism to prevent the attack. Mitigations can be features of the framework (e.g. credentials are signed by issuers), can be mechanisms offered by underlying OS or network (e.g. private keys are stored in the machine's key store) or can be missing (e.g. not implemented). In this last case, the threat is not mitigated. However, it is useful to know that this threat exists. For instance, the fact that non-repudiation is not ensured for message X in component Y can be acceptable for a type of application but when the same component would be reused in another application, mitigation may be necessary.

For mitigation, the following are used:

Implemented Mitigation means that the mitigation is implemented and used in the demonstrator.

Exisiting Mitigation means that there is an existingmitigation that could be used without implementation specific to TAS³. For instance using https or a firewall would mitigate the attack.

Not Implemented Mitigation means that the mitigation has not been implemented. A solution is known but more development is required to use it.

No Mitigation means that there is no solution to mitigate the attack. In this case the attack has to be "acceptable".

When multiple mitigations exist, they are listed in the tree, i.e. by default there is an "or" operator between tree's nodes where Implemented or :(equals Implemented.

1. Input / Data Validation

    - Assume all input is malicious.

- Centralize your approach.
- Do not rely on client-side validation.
- Be careful with canonicalization issues.
- Reject known bad input
- Constrain input.
- Validate data for type, length, format, and range.
- Reject known bad input.
- Sanitize input.
- Encrypt sensitive cookie state.
- Make sure that users do not bypass your checks.
- Validate all values sent from the client.
- Do not trust HTTP header information.
- Encrypt sensitive cookie state.
- Do not trust fields that the client can manipulate (query strings, form fields, cookies, or HTTP headers).
- Validate all values sent from the client.
- Do not trust input
- Consider centralized input validation.
- Do not rely on client-side validation.
- Be careful with canonicalization issues.
- Constrain, reject, and sanitize input.
- Validate for type, length, format, and range.

2. Authentication

- Do not use passwords. Use hardware authentication tokens instead.
- Separate public and restricted areas.
- Use account lockout policies for end-user accounts.
- Support password expiration periods.
- Be able to disable accounts.
- Do not store passwords in user stores.
- Use strong passwords.
- Do not send passwords over the wire in plaintext.
- Protect authentication cookies.
- Partition site by anonymous, identified, and authenticated area.
- Support password expiration periods and account disablement.
- Do not store credentials (use one-way hashes with salt).

- Encrypt communication channels to protect authentication tokens.
- Pass Forms authentication cookies only over HTTPS connections.

3. Authorization

- Use multiple gatekeepers.
- Restrict user access to system-level resources.
- Consider authorization granularity.
- Use least privileged accounts.
- Consider authorization granularity.
- Enforce separation of privileges.
- Restrict user access to system-level resources.

4. Auditing and Logging

- Audit and log access across application tiers.
- Consider identity flow.
- Log key events.
- Secure log files.
- Back up and analyze log files regularly.
- Identify malicious behavior.
- Know what good traffic looks like.
- Audit and log activity through all of the application tiers.
- Secure access to log files.

5. Configuration Management

- Secure your configuration store.
- Maintain separate administration privileges.
- Use least privileged process and service accounts.
- Do not store credentials in plaintext.
- Use strong authentication and authorization on administration interfaces.
- Do not use the LSA.
- Secure the communication channel for remote administration.
- Avoid storing sensitive data in the Web space.

6. Sensitive Data

- Do not store database connections, passwords, or keys in plaintext.
- Avoid storing secrets in the Local Security Authority (LSA).
- Retrieve sensitive data on demand.
- Encrypt the data or secure the communication channel.

- Do not store sensitive data in persistent cookies.
- Do not pass sensitive data using the HTTP-GET protocol.
- Avoid storing secrets.
- Secure the communication channel.
- Provide strong access controls on sensitive data stores.

7. Session Management

- Use SSL to protect session authentication cookies.
- Encrypt the contents of the authentication cookies.
- Limit session lifetime.
- Protect session state from unauthorized access. Secure the channel.
- Encrypt the contents of authentication cookies.
- Protect session state from unauthorized access.

8. Cryptography

- Do not develop your own cryptography.
- Use the correct algorithm and correct key size.
- Secure your encryption keys.
- Use tried and tested platform features.
- Keep unencrypted data close to the algorithm.
- Cycle your keys periodically.
- Store keys in a restricted location.
- Exception Management
- Do not leak information to the client.
- Log detailed error messages.
- Catch exceptions.
- Use structured exception handling.
- Do not reveal sensitive application implementation details.
- Do not log private data such as passwords.
- Consider a centralized exception management framework.

B.6 T3-ACVS: Authorization Credential Validation Service

This is part of the T3-PEP-AI component.

B.7 T3-BP-CLIENT: Business Process User Interface

B.7.1 Entry points

i. Intended entry point: User interface

ii. Intended entry point: SSO-related Communication with IdP

iii. Intended entry point :Communication to BP-Engine - Starting process instances, creating and completing tasks

iv. Internal entry point: Policy Store

v. Intended entry point : Decision requests to the T3-PDP-BP

B.7.2 Asset: State of process instances, confidentiality and integrity of process data

i. Ability to start processes

ii. Ability to complete tasks

iii. Access to process data

Threat 1 Unauthorized access to tasks (i.e., viewing or completing tasks).

Attack Session hijacking attack

Mitigation Implemented Usage of SSL to protect

```
session authentication cookies
```

Mitigation Implemented Limit session lifetime

Threat 2 Phishing attack.

An attacker can present a site similar to the T3-BP-CLIENT to the user and make him confuse this fake site with the real site. It can thus trick him to enter confidential information because he believes a legitimate business process requests the information.

Mitigation Implemented Use SSL certificate

Use an SSL certificate to proof the site's identity. This should be accompanied by teaching users basic security precautions on the Web.

B.8 T3-BP-DEL: Business Process Delegation Service

B.8.1 Entry points

i. Intended entry point: Interface for re-assigning tasks to another user

ii. Internal entry point: Decision requests to the T3-PDP-BP

iii. Internal entry point: Registration of changed task assignment in the T3-BP-PIP

B.8.2 Asset: Integrity of user-task assignment

The current functionality of the T3-BP-DEL is re-assignment of tasks from one user to another. Normally, requests to do so are authenticated and authorized.

Threat 1 Assignment of tasks caused by other user than the current owner (or an authorized administrator)

Attack Pose as another user when requesting task-reassignment

Existing mitigation Use TAS³ authentication mechanism (identity assertions) to validate requests.

Threat 2 Re-assignment of tasks to non-authorized users

Attack Spoof PDP response

Implemented mitigation PDP and T3-BP-DEL run on the same dedicated machine.

Existing mitigitation Encrypt and sign communication with PDP

B.9 T3-BP-ENGINE-ODE: Apache ODE Business Process Execution Engine

B.9.1 Entry points

i. Intended entry point: Process deployment

ii. Internal entry point: Interaction with BP-Client

iii. Internal entry point: Interfaces for communication with PEP

B.9.2 Asset: Executable process models

Process models define the behavior of applications and deal with sensitive information.

Threat 1 Flawed business process with unintended behavior

Attack Unauthorized deployment of of process models

Implemented mitigation Password authentication of administrator access to process deployment

Existing mitigation Strong authentication (cryptographic identity assertions)

Not implemented mitigation Fine-grained authorization rules for process models.

Not implemented mitigation Logging of modifications to process models.

B.9.3 Asset: Running process instances (state and data)

The engine executes instances of business processes. Correct application behavior relies on the state and data of these instances.

Threat Stopping running process instances

If running business process instances are stopped, they won't complete, possibly causing inconsistent behavior, and preventing reaching the application goal.

Attack Unauthorized access to administration interface

Implemented mitigation Password authentication of administrator access to process deployment

Existing mitigation Strong authentication (cryptographic identity assertions)

Not implemented mitigation Fine-grained authorization rules for process models.

Not implemented mitigation Logging of modifications to process models.

B.10 T3-BP-ENGINE-ODE: Apache ODE Business Process Execution Engine

B.10.1 Entry points

i. Intended entry point: Process deployment

ii. Internal entry point: Interaction with BP-Client

iii. Internal entry point: Interfaces for communication with PEP

B.10.2 Asset: Executable process models

Process models define the behavior of applications and deal with sensitive information.

Threat Flawed business process with unintended behavior

Attack Unauthorized deployment of of process models

Implemented mitigation Password authentication of administrator access to process deployment

Existing mitigation Strong authentication (cryptographic identity assertions)

Not implemented mitigation Fine-grained authorization rules for process models.

Not implemented mitigation Logging of modifications to process models.

B.10.3 Asset: Running process instances (state and data)

The engine executes instances of business processes. Correct application behavior relies on the state and data of these instances.

Threat Stopping running process instances

If running business process instances are stopped, they won't complete, possibly causing inconsistent behavior, and preventing reaching the application goal.

Attack Unauthorized access to administration interface

Implemented mitigation Password authentication of administrator access to process deployment

Existing mitigation Strong authentication (cryptographic identity assertions)

Not implemented mitigation Fine-grained authorization rules for process models.

Not implemented mitigation Logging of modifications to process models.

B.11 T3-BP-MGR: Business Process Administration Interface

B.11.1 Entry points

i. Internal entry point: Communication with T3-BP-ENGINE-ODE

ii. Intended entry point: Graphical user interface

B.11.2 Asset: Status of business process instances

The T3-BP-MGR will trigger adaption of business process models and especially the migration of running business process instances to a new version of a model.

Threat Unauthorized alteration of business process instances, unauthorized disclosure of process instance status.

Attack 1 Spoofing identity of authorized user in communication between T3-BP-MGR and the engine.

Existing mitigation Strong authentication (cryptographic identity assertions)

Attack 2 Illegitimate operations by authorized users.

The user might use a altered client software. If checks only occur at client side, the user might be able to perform unauthorized actions in the engine.

Not implemented mitigation Perform all necessary checks (also) on server side.

Existing mitigation Log all activities for audit purposes, limit the people allowed to perform management activities on the engine.

Attack 3 Spyware

An attacker can try to provide the user with an altered client software, which requests the user to authenticate normally, but makes other requests than what the user thinks he has authorized.

Existing mitigation Control software installation on the user's computer.

If software installation is not controlled, the user's system has to be considered insecure anyway, which makes it prone to all sorts of attacks.

B.12 T3-BP-PEP: Business Process Policy Enforcement Point

B.12.1 Entry points

i. Internal entry point: Communication between PEP and PIP

ii. Internal entry point: Communication between PEP and T3-BP-ENGINE-ODE

iii. Internal entry point: Communication with T3-PDP-BP (policy decision requests and responses)

B.12.2 Asset: Correct policy enforcement

Threat 1 A process communicates without policy enforcement

Attack 1 Process models containing direct calls to third party web services, bypassing the PEP

Implemented mitigation Manual check of process models

Not implemented mitigation Automatic check of process models

Not implemented mitigation Integration of the PEP as a layer in the web service stack of the execution engine

Attack 2 Calling the process' web service interfaces directly, bypassing the PEP

Existing mitigation Block access from outside using a firewall.

Not implemented mitigation Integration of the PEP as a layer in the web service stack of the execution engine

Threat 2 Tricking PEP into using a rogue PDP

Attack Changing PDP address in PEP configuration.

Implemented mitigation Protect PEP code and configuration from unauthorized alteration using file system permissions.

B.13 T3-BP-PIP: Business Process Policy Information Point

B.13.1 Entry points

i. Internal entry point: Communication between PEP and PIP

ii. Communication with T3-BP-ENGINE-ODE

iii. Communication with PDP

B.13.2 Asset: Correct information for policy enforcement

Threat 1 Context information about processes not up to date.

The context of a process (current point of execution, assigned users) continuously changes. Up-to-date information is necessary for correct policy enforcement.

Attack Interrupt communication between engine and PIP. Implemented mitigation: Run engine and PIP on the same dedicated machine.

`This makes it much harder to interrupt communication.`

Existing mitigation Enforce a time-to-live on information in the PIP, check directly on the engine if TTL is expired.

Threat 2: PIP accepts and provides `invalid/untrusted` context information.

Attack Push incorrect context information to the PIP.

Existing mitigation Cryptographically sign messages to the PIP.

Existing mitigation Correctly configure trusted sources.

Existing mitigation Only accept input from the same host (using a firewall) which only runs BP-related component.

B.14 T3-BP-SMC: Business Process Security Configuration Component

The T3-BP-SMC processes security specifications for business processes (either as annotations or separate specifications) and translates them into business process related security configuration (e.g. business process policies) and enhances business process models with explicit security subprocesses.

B.14.1 Entry points

i. Intended interface: Security configuration user interface

ii. Intended interface: Processing of annotations to business process model security enhancements

iii. Intended interface: Processing of additional business process security configuration

iv. Internal interface: Deployment of security configuration to runtime components.

B.14.2 Asset: Business process security annotations and security

Threat 1 Inaccurate use of business process security annotations or specifications

Attack Process security modeler makes faulty or incomplete security annotations or specifications

Mitigation Process security modeler has to be trained for working with business process security annotations and specifications.

Threat 2 Unauthorized modification of business process security annotations or specifications

Attack Unauthorized person changes the security configuration of a business process.

Not implemented mitigation User access control for SMC component, for business process models with security annotations and for security specification files.

B.14.3 Asset: Security enhanced business process models and business process security configurations generated by the SMC component

Threat Unauthorized modification of security enhanced business process models or security configurations.

Attack Unauthorized person changes the security configuration of a business process or the security enhanced business process itself.

Not implemented mitigation Secured deployment of business processes and appropriate security configurations from the SMC component to the business process engine (T3-BPENGINE-ODE): Webservice calls with signed file transfer.

Implemented Mitigation User access control on application and file system level for the business process engine.

B.15 T3-BUS-AUD: Audit Event Bus

B.15.1 Entry points

i. Intended Entry point: Interface with subscription clients

ii. Intended Entry point: Interface with notification clients

iii. Intended Entry point: Interface with update clients

B.15.2 Asset: Channels of audit event type

Threat Overload of service creating failure in audit notifications

Attack Denial of service

Not Implemented Mitigation To prevent a denial of service attack the services calling the audit bus will be limited to specific pre- authenticated TAS³ infrastructure services. Specific terms of behaviour will govern these services and the Audit Bus will be monitored to detect if a service making calls to the bus is in breach of these (an example could be behaviour that can be deemed as a denial of service attack). In this case the offending service will be reported to the appropriate authority and blacklisted from calling the bus. The architecture will also be designed to allow scaling and multiple audit bus implementations to manage load better.

B.15.3 Asset: Status of audit event type

Threat 1 Unauthorised invocation of the audit bus

Attack Unauthorised access to audit bus Web service interface

Not Implemented Mitigation In order to update the status of an audit event or invoke the bus a token will be needed. The token is used to present the correct credentials to the audit bus server. This token comes from the main TAS³ authorisation infrastructure.

Threat 2 Audit bus notification leak

Attack Unauthorised access to audit bus notifications

B.16 T3-DEL: Delegation Service

B.16.1 Entry points

i. SOAP web interface

ii. Apache PHP client

iii. Shell or root shell administrative login

B.16.2 Assets

i. Issued credentials (these are cryptographically protected)

ii. Private signing key of the delegation issuing service

iii. Configuration file (list of trusted proxies)

iv. Trust store of the delegation issuing service (application server)

v. The delegation policy (this is cryptographically protected)

B.16.3 Threats

i. Unauthorized delegation

ii. Unauthorized revocation (leading to denial-of-service)

iii. Denial-of-service attack so that authorised requests will be denied

Attack 1 Compromising the private signing key of the service.

A compromise of the signing key of the delegation issuing service could lead to fake credentials being issued, and hence to unauthorized delegations.

Existing Mitigation Keep the private key of the delegation issuing service in a password protected key store. Use file system permissions to prevent the service configuration file from being read by any entity except the application server running the service. Use an account with limited capabilities (no login shell) to run the application server. If no direct access to the delegation issuing service is required (e.g. when accessing service through a trusted proxy) the application server can be kept behind a firewall.

Attack 2: Listing oneself as a trusted proxy.

By definition, a trusted proxy is trusted to tell the delegation issuing service who the actual issuer is. If one can add oneself to the list of trusted proxies and obtain an SSL certificate that will be trusted by delegation issuing service (or its application server) then one can make false issuing requests (that will be accepted if they obey the delegation policy). Likewise, once the delegation issuing service is fooled into thinking that one is a trusted proxy, one can make bogus revocation requests.

Existing Mitigation: Use file system permission to prevent unauthorized modification of the service configuration file (which contains the list of trusted proxies). Alternatively digitally sign the configuration file. Or use a password protected trust store to prevent unauthorized modification of it. Use a reputable CA, or an in house CA (with an off line private key) to issue SSL certificates to the trusted proxies.

Attack 3 Modifying or replacing the delegation policy.

If one can modify the delegation policy then one can for instance add oneself as a trusted attribute issuer, or add oneself as a member of a specific domain etc.

Implemented Mitigation Use a (self-signed) X.509 AC to hold the delegation policy. Use signature verification prior to loading the policy to ensure the integrity of the X.509 AC. Use file system permissions to protect the delegation issuing service's configuration files from unauthorized modification. This configuration file contains the policy reference, policy location and the certificates that are the roots of trust of the signature verification process.

Attack 4 Gaining access to the credential repository.

Since the credentials are digitally signed then it is not possible to either modify a credential or mint a new one without access to the signing key. If an attacker gains access to the credential repository she can only delete the credentials in the repository. This will have the effect that legitimate access requests will be denied by a PDP when configured to pull from this repository.

Existing Mitigation Restrict access to the credential repository by for instance keeping it behind a firewall. When using an LDAP repository configure it so that the login credentials given write access to the repository cannot be obtained by simply sniffing the network.

Attack 5 Obtain the password of a legitimate user of the DIS client.

Once an attacker has obtained the password of a legitimate user of the DIS client, then she can make false delegation requests.

Existing Mitigation Use an SSL connection to protect the password from being visible on the Internet. Configure the (Apache) web server to not serve the DIS client pages on a http only connection. Ensure that user passwords are strong and impossible to dictionary attack.

B.17 T3-IDP-ACSIS

B.17.1 Entry points

i. Shell or root shell (or ssh) administrative login

ii. TAS³ designed management interfaces (none yet)

iii. Product specific management interfaces

- - New user registration (feature to allow anonymous new user to self register)
- - Auto-CoT (fully automatic metadata exchange and trust establishment with anonymous third party SPs)
- - New service registration (feature to allow anonymous 3rd party to register new services)

iv. Web GUI

v. SOAP web service

- - SSO
- - SLO
- - Discovery query

B.17.2 Data assets

i. Private keys of the service itself

ii. Circle-of-Trust database

iii. Discovery Registrations

iv. User database

- • User names
- • Authentication credentials (password hash, Yubikey shared secret)
- • User's attribute data

v. Federation database: name id mappings

vi. Session store

B.17.3 Nonfunctional assets

i. Privacy preserving through avoidance of correlation handles

ii. User consent and control of data release

iii. Organizational control of data release

iv. Nonrepudiation

v. Accountability

vi. Credible authentication of users

vii. Credible authentication of system entities

B.17.4 Attacks and mitigation

- Too numerous to describe exhaustively in one afternoon *** TBD

- Generally the data assets are protected using Unix filesystem permissions against shell and local Unix process access. This, of course, is of little value against root. Therefore deployment MUST use nonroot users for running all TAS³ related processes as well as for most administrative tasks.
- The TAS³ designed and product specific management interfaces follow good coding practises (e.g. check for ".." in path) to only allow designed access to the data assets.
- Web GUI is coded such that only authorized accesses are possible
- SOAP web service is coded such that only authorized accesses are possible
- Appropriate crypto layer (such as TLS) is applied in Web GUI, SOAP, and ssh entry points

B.18 T3-IDP-SHIB: Shibboleth IDP

B.18.1 Entry Points

i. SOAP Authentication Service Endpoint

ii. SOAP Attribute Authority Endpoint

iii. Shell or root shell administrative login

B.18.2 Asset: Issued Credentials

Threat Issues Credentials used by More than One Party

Attack Replay Attack

If intercepted by a third party, credentials may be submitted to the SP at which they are valid multiple times. Without adequate replay protection this may allow multiple users to access the service using the same set of credentials

Existing Mitigation Replay Detection

Implement checks at the SP to log the details of each incoming message so that if the same message is passed to the SP multiple times it can be recognised and the presenter denied access.

B.18.3 Asset: Private Signing Keys of the Service

Threat Private Signing Key of the Service is Compromised

A compromise of the signing key of the modified IdP could lead to fake attribute or authorisation credentials being issued, and allow an untrusted service to masquerade as the IdP entity.

Attack Attacker Gains Access to Machine Hosting the Service

Existing Mitigation Use Password Protected Key Store

Keep the private key of the IdP in a password protected key store.

Existing Mitigation Use File System Permissions

Use file system permissions to prevent the service configuration file from being read by any entity except the application server running the service.

Existing Mitigation Use Restricted Account

Use an account with limited capabilities (no login shell) to run the application server.

Existing Mitigation Restrict Access to Service

If no direct access to the IdP is required (e.g. when accessing service through a trusted proxy) the application server can be kept behind a firewall.

B.18.4 Asset: User Database (Attributes and Authentication Credentials)

Threat 1 User Authentication Credentials are Compromised

Once an attacker has obtained the password of a legitimate user of the IdP client, then she can masquerade as the user throughout the federation.

Attack 1 Dictionary attack

An attacker may attempt to obtain the username / password combination of a legitimate user of the IdP by performing a dictionary attack on the authentication page.

Implemented Mitigation Restriction of Number of Authentication Requests

The authentication endpoint should monitor the number of authentication attempts that are made for each incoming authentication session. After a configurable number of failed authentication attempts have been made the authentication attempt should fail and return an error message to the requesting SP.

Attack 2 Network Sniffing

Implemented Mitigation Use SSL/TLS connection

Use an SSL connection to protect the password from being visible on the Internet. Con- figure the (Apache) web server to not serve the IdP authentication pages on a http only connection.

Implemented Mitigation Use Different Authentication Mechanism

Implement two factor or challenge/response authentication mechanisms to increase the user's level of assurance.

Threat 2 IdP Assertions are Reused (Credential Theft)

Attack Assertions are Stolen

Once issued by the IdP attribute and authorisation credentials may be stolen in transit by an intermediary and presented to another SP in order to grant another user access.

Implemented Mitigation:: Limited Life Time

Every credential should be short lived to prevent an attacker having unlimited time to reuse the credential.

Implemented Mitigation:: Restrict SPs at which Assertion is valid

Each credential should be encrypted to the intended recipient making the credential worthless to all but the intended recipient. SPs should obey any audience restriction present in the assertion.

Implemented Mitigation:: Tie Authentication and Attribute Assertion Together

Each attribute credential should contain a Subject that is identical to that of the Subject of the preceding authentication assertion to prevent it from being used as part of a different session.

Threat 3 User Attributes are Disclosed to Unauthorised Party

User attributes should not be disclosed to unauthorized parties.

Attack Network Sniffing

Implemented Mitigation Use of Cryptographic Techniques

All incoming messages are encrypted using the IdPs public key and the IdP encrypts all outgoing messages using the public key of the recipient SP.

Threat 4 Compromise of Backend Database / LDAP Server

If an attacker can access or modify the backend database/LDAP server then she may be able to edit the credentials.

Attack Unauthorised Access Gained to Backend Data Store

Existing Mitigation Use of Firewall

Use a firewall to restrict access to the backend data store. This need not be accessible from the Internet, even if the IdP has to be.

Existing Mitigation Use of SSL/TLS

When administrator access is needed to the backend data store, then the credentials should not be conveyed in clear text. Communication with the database should either be local or over SSL.

B.18.5 Asset: Session Information

B.18.6 Asset: Configuration Files of the Service

Threat Unauthorised Modification of the Configuration Files

If an attacker can modify the IdPs configuration files then they can edit the attributes that will be released from the IdP, add additional un-trusted attribute sources, or remove security precautions such as the signing and encryption of outgoing messages.

Attack Attacker Gains Unauthorised Access and Modifies Configuration Files

Existing Mitigation Use of File System Permissions

Use file system permissions to prevent the service configuration files from being read by any entity except the application server running the service.

Existing Mitigation Use of Restricted Account

Use an account with limited capabilities (no login shell) to run the application server.

B.18.7 Non-functional Asset: User Consent and Control of Data Release

B.18.8 Non-functional Asset: Organisation Control of Data Release

B.19 T3-IDP-SHIB-AGG: Enhancement to Shibboleth IDP to support attribute aggregation

Please note: The more general risk analysis presented in preceding Section 2.18 for the Shibboleth IdP also applies to this section. The additional risks presented below apply only to the changes required to support aggregation.

B.19.1 Entry points

i. SOAP web interface for auditing

ii. SOAP web interface for enquiries

iii. Administrative shell login

iv. Application management console of application server

B.19.2 Asset: The Audit Trail

Threat 1 Modification of Audit Trail

Attack Attacker Accesses Auditing Service Machine and Modifies/Deletes the Audit Trail

An attacker may gain unauthorized access to the machine hosting the logging service. In this way she may be able to modify or remove the audit trail.

Implemented Mitigation Cryptographic Protection

The SAWS audit trail structure uses cryptographic techniques to ensure that unauthorized modification of the audit trail will not go unnoticed. It uses heartbeats to ensure that records are not removed from the end. It chains audit files together to ensure that complete audit files cannot be deleted without notice. It periodically creates new audit files to ensure they do not become too long.

Existing Mitigation File System Permissions

Use file system permissions to restrict access to the audit trail, e.g. only allow the appli- cation server's account to write to the file.

Existing Mitigation Use Restricted Account

Run the application server with a restricted account (e.g. an account without a login shell). Restrict access to the machine hosting the logging service by e.g. running it behind a firewall if possible.

Existing Mitigation Backup the Audit Trail

Periodically backup complete audit files to CD-ROM or similar to prevent loss or modi- fication in case of an attack.

Threat 2 Unauthorised Disclosure of Audit Trail Contents

Attack 1 Attacker Obtains Complete Copy of Audit Trail

If the machine hosting the audit service (or one of the machines holding the backup of the audit trail) is compromised then it may be possible that the attacker gets to read access to audit information that she shouldn't be able to read.

Implemented Mitigation Encryption of Audit Trail Data

If confidentiality of the audited data is important then the audit service can be configured to encrypt the audited data with a symmetric key. This symmetric key is stored in the audit trail, encrypted with the public key of the persons authorised to read the contents of the trail. In this way, the audit trail is not readable by subjects not having one of the correct private keys.

Attack 2 Attacker Abuses the Enquiry Service

An attacker may abuse the enquiry service by issuing search requests for data that she isn't allowed to see.

Existing Mitigation Use Authorisation on Enquiry Service

The enquiry service is still in an embryonic state of implementation, but it is envisaged that a PDP will be used both before searching the audit trail and to filter the results re- turned to the requester. The enquiry service will run over SSL and will require client authentication, possibly using a list of trusted proxies to say who the actual requester is.

B.19.3 Asset: SAWS Records a Secure Audit Trail

Threat Denial of Service for Legitimate Clients

Attack Attacker Swamps Service with Requests

Implemented Mitigation Only Allow Known Clients

The auditing service only accepts messages from known clients. This is ensured by con- figuring the application server to run the auditing service over SSL only. The application server has to be configured to require client authentication. Configure the trust store to only accept messages from clients having a certificate issued by a trusted CA. Further, the SAWS configuration file contains a list of known clients; only these are allowed to add messages to the audit trail.

Existing Mitigation Use Firewall

When the IP-addresses of the attacker are known these can already be blocked on the level of the (operating-system) firewall, so that they never reach the application server.

B.19.4 Asset: Private Keys for Signing/Encrypting

Threat Compromise of the Private Signing or Encryption Key

Attack Attacker Gains Access to Machine Hosting Auditing Service

An attacker may gain access to the machine hosting the audit service and in this way obtain a copy of service's secrets. For instance, if a copy of the private signing key is obtained, then an attacker would be able to modify the audit trail without this being noticed.

Implemented Mitigation Use of Password Protected Key Stores

Use password protected key stores (which can optionally require more than one password to be opened) to hold the service's secrets. The passwords are asked for interactively and are not stored in the configuration file. Only when automatic (i.e. without human intervention) start up of the service is required do you need to store passwords in a file. This file should be properly protected using file system permissions and should only be readable by the application server hosting the audit service.

Existing Mitigation Use of TPM to Store Secrets

The encrypted software keystore could be replaced with a hardware TPM based keystore which will forbid tampering or unauthorised access.

Existing Mitigation File System Permissions

B.20 T3-LOG-SAWS: Secure Auditing Web Service

B.20.1 Entry points

i. SOAP web interface for auditing

ii. SOAP web interface for enquiries

iii. Administrative shell login

iv. Application management console of application server

B.20.2 Asset: The Audit Trail

Threat 1 Modification of Audit Trail

Attack Attacker Accesses Auditing Service Machine and Modifies/Deletes the Audit Trail

An attacker may gain unauthorized access to the machine hosting the logging service. In this way she may be able to modify or remove the audit trail.

Implemented Mitigation Cryptographic Protection

The SAWS audit trail structure uses cryptographic techniques to ensure that unauthorized modification of the audit trail will not go unnoticed. It uses heartbeats to ensure that records are not removed from the end. It chains audit files together to ensure that complete audit files cannot be deleted without notice. It periodically creates new audit files to ensure they do not become too long.

Existing Mitigation File System Permissions

Use file system permissions to restrict access to the audit trail, e.g. only allow the appli- cation server's account to write to the file.

Existing Mitigation Use Restricted Account

Run the application server with a restricted account (e.g. an account without a login shell). Restrict access to the machine hosting the logging service by e.g. running it behind a firewall if possible.

Existing Mitigation Backup the Audit Trail

Periodically backup complete audit files to CD-ROM or similar to prevent loss or modification in case of an attack.

Threat 2 Unauthorised Disclosure of Audit Trail Contents

Attack 1 Attacker Obtains Complete Copy of Audit Trail

If the machine hosting the audit service (or one of the machines holding the backup of the audit trail) is compromised then it may be possible that the attacker gets to read access to audit information that she shouldn't be able to read.

Implemented Mitigation Encryption of Audit Trail Data

If confidentiality of the audited data is important then the audit service can be configured to encrypt the audited data with a symmetric key. This symmetric key is stored in the audit trail, encrypted with the public key of the persons authorised to read the contents of the trail. In this way, the audit trail is not readable by subjects not having one of the correct private keys.

Attack 2 Attacker Abuses the Enquiry Service

An attacker may abuse the enquiry service by issuing search requests for data that she isn't allowed to see.

Existing Mitigation Use Authorisation on Enquiry Service

The enquiry service is still in an embryonic state of implementation, but it is envisaged that a PDP will be used both before searching the audit trail and to filter the results re- turned to the requester. The enquiry service will run over SSL and will require client authentication, possibly using a list of trusted proxies to say who the actual requester is.

B.20.3 Asset: SAWS Records a Secure Audit Trail

Threat Denial of Service for Legitimate Clients

Attack Attacker Swamps Service with Requests

Implemented Mitigation Only Allow Known Clients

The auditing service only accepts messages from known clients. This is ensured by con- figuring the application server to run the auditing service over SSL only. The application server has to be configured to require client authentication. Configure the trust store to only accept messages from clients having a certificate issued by a trusted CA. Further, the SAWS configuration file contains a list of known clients; only these are allowed to add messages to the audit trail.

Existing Mitigation Use Firewall

When the IP-addresses of the attacker are known these can already be blocked on the level of the (operating-system) firewall, so that they never reach the application server.

B.20.4 Asset: Private Keys for Signing/Encrypting

Threat Compromise of the Private Signing or Encryption Key

Attack Attacker Gains Access to Machine Hosting Auditing Service

An attacker may gain access to the machine hosting the audit service and in this way obtain a copy of service's secrets. For instance, if a copy of the private signing key is obtained, then an attacker would be able to modify the audit trail without this being noticed.

Implemented Mitigation Use of Password Protected Key Stores

Use password protected key stores (which can optionally require more than one password to be opened) to hold the service's secrets. The passwords are asked for interactively and are not stored in the configuration file. Only when automatic (i.e. without human intervention) start up of the service is required do you need to store passwords in a file. This file should be properly protected using file system permissions and should only be readable by the application server hosting the audit service.

Existing Implementation Use of TPM to Store Secrets

The encrypted software keystore could be replaced with a hardware TPM based keystore which will forbid tampering or unauthorised access.

Existing Mitigation File System Permissions

B.21 T3-LOG-WRAP-SAWS: Wrapper Web service around SAWS with extensions

B.21.1 Entry points

o. SOAP client

B.21.2 Asset: Audit Trails

Threat 1 Traceless Exploitation

Attack Attackers exploit an application without leaving a trace

Mitigation Identify malicious behaviour.

Threat 2 Disguising the attack

Attack Attackers cover their tracks

Existing Mitigation Using audit/log files

Existing Mitigation Audit and log activity through all of the application tiers.

Existing Mitigation Secure access to log files.

B.22 T3-OCT: Online Compliance Testing

The TAS³ architecture supports a novel testing approach for services that are running within a TAS³ choreography. Such approach is implemented within the TAS³ architecture by the OCT (On-line Com- pliance Testing) component. The novel idea behind OCT is that services are submitted to the execution of a set of test cases in their real execution environment, while they possibly interact with other services. The service under tests are unaware that some invocation they receive comes from OCT. OCT validation may be performed periodically or after some relevant event, aiming at verifying that every service in the TAS³ federation abides by the manifested policies and/or complies with the functional specifications. As detailed in D10.2, on-line testing in TAS³ is applied in order to reduce the risk that services within a circle of trust (i.e. service federation) will get in contact with unreliable services. Therefore services within the federation will be regularly submitted to on-line testing to assess that they comply with their public and manifested policies. Also, the scenario we foreseen for OCT assumes that, within the federation, services admit that different requesters may play different roles. Service clients collect credentials in order to prove the role that they are playing as requesters. Thus, the authorization/authentication layers in TAS³ (e.g. the IdP components) collaborates with OCT components signing role assertions that would be used in running the test cases.

Note that the OCT components uses the security layer provided by the TAS³ architecture. Thus it exists a strict dependency in term of security vulnerabilities with the issues described for the T3-STACK and the component T3-SSO-ZXID (see Section 4.39).

B.22.1 Entry points

i. Intended Entry Point: SOAP Binding with the IdP

ii. Internal Entry Point: The API of the OCT component, used in order to implement the test-driver

B.22.2 Non-Functional Assets

i. the OCT component credentials

ii. user/test user credentials

iii. QoS of the service under test

The following threats are relate to the non functional assets

Threat 1 The service under test have to be unaware of the TAS³ testing session, the credential issued for testing purposes can be actually spent as valid credential within the federation.Malicious services may obtain from the IdP credential that was originally issued only for testing purposes and use them illicitly.

Attack 1 Man in the middle

Malicious services can sniff the communication between the OCTcomponent and the IdPs in TAS³

Attack 2 Spoofing

Malicious services masquerade their interaction to the IdP as the OCT component. Implemented Mitigation::

i. Usage of SSL or TLS Client Certificate toprotect session authentication in the communication between the OCT component and the

ii. Use the security assets of the TAS³ -STACK

iii. Limit session lifetime

Threat 2 A massive use of the on-line testing process can affect the QoS of the service under test.

Attack Denial of Service (DoS)

Malicious services that have gained the OCT credential can exploit them running Denial-Of- Services attacks to other services in the TAS³ choreography

Implemented Mitigation Use the security assets of the TAS³ -STACK

Threat 3 The credential used during an on-line testing session may have undesired effect on actual users.

The threat 4.18.2.5 does not refer to any specific attack. However, as potential errors and failures of the on-line testing activity may generate unconsidered security leak affecting real user, we recommended some implemented mitigations for this threat.

Implemented Mitigation Create and use realistic test user

B.23 T3-OCT-PLANNER: Test Planner for the Online Compliance Testing

The TAS³ -OCT-PLANNER is an off-line component. With respect to the TAS³ Architecture it belongs to the Modeling & Configuration Management

Realm. In particular, the TAS³ -OCT-PLANNER can be used off-line in order to moel test cases, and it is not affected by run-time security issues.

B.24 T3-PDP-BP: Business Process Policy Decision Point

The need of this component is currently not clear; see PDP-M and PDP-P for possible attacks;

B.25 TAS³ -ONT-SER: Ontology Server

B.25.1 Entry Points

- Command line access
- J2EE Interface: uses JBoss, which provides means for security (authentication, etc.)

Intended Entry point:

i. J2EE Bean delegating calls to internal beans

ii. LEXONBASE (CRUD LEXON & CONTEXT)

iii. COMMITMENT (CRUD COMMITMENT)

iv. VERSIONNING (prototype)

v. PERSPECTIVE CONFLICT MANAGEMENT (prototype)

B.25.2 Asset: Ontology Server

Threat Trust Policy Disclosure/Modification (heading4)

Attack 1 The administrator access to the repository and disclose/change the trust policies

Existing Mitigation External Monitoring and Logging mechanism

Standard provided by JBoss for the application server WEB CONSOLE + logging via shell Keeping of who modified what in the business layer

Attack 2 Unauthorized access to the ontology server

Existing Mitigation Logging and monitoring mechanisms

The data assets are stored in a Postgres database on a Linux server, which is protected through the login to the database.

The J2EE interface uses username and passwords to enable authorised access to the data. The REST interface will be implemented and will give authorised access to people with the right `credentials/tokens`.

Existing Mitigation: Use of authorization mechanisms

- provided by JBoss
- IP blocked for 10 minutes after 3 unsuccessful logins (prevent intrusion
- no open ports

Attack 3 forcing the access to the database

Existing Mitigation Use of secure channels for data transmissions (i.e. HTTPS)

B.26 T3-PDP-BTG: Break the Glass PDP

This is part of theT3-PEP-AI component. Here we discuss an additional asset specific to the T3-PDP- BTG

B.26.1 Entry points

See entry points of T3-PEP-AI.

B.26.2 Asset: The BTG-State of the System

Threat Unauthorised Modification of the BTG-State

When an attacker manages to modify the BTG state, then she may be able to get access to certain resources without actually breaking the glass, hereby circumventing any obligations (such as audit and notification) that may be associated with breaking the glass.

Attack Gain Access to Machine Hosting BTG-State and Modify It

Existing Mitigation In-Memory Only Implementation

The BTG-state is implemented in-memory only, making it hard for an attacker to modify it as the operating system manages the boundaries between the memory areas assigned to different applications.

B.27 T3-PDP-M: Policy Decision Point/Master PDP

This is part of theT3-PEP-AI component.

B.28 T3-PDP-P: PERMIS PDP

B.28.1 Entry Points

i. Java API

B.28.2 Asset: Authorisation Policy

Threat Policy is Modified

Attack Attacker Modifies Authorisation Policy

An attacker tries to edit the authorisation policy in order to grant access to people who should not have access or deny access to people who should have access.

Implemented Mitigation Cryptographic Protection

The PERMIS policy is designed to be digitally signed and the PERMIS engine validates the signature at start up time. Hence an attacker would need to gain access to the private key of the policy author in order to effectively edit the policy.

B.29 T3-PDP-T: Trust Policy Decision Point

B.29.1 Entry points

i. Internal Entry point: Shell or root shell

ii. Intended Entry point: Trust PDP Evaluation Request

iii. Intended Entry point: Trust PDP Call-back Function

iv. Intended Entry point: Returned value from Trust Service call

v. Intended Entry point: Trust Policy Repository Interfaces

B.29.2 Asset: Trust Policy

Threat Trust Policy Disclosure/Modification

A malicious agent accesses the trust policies and discloses or manipulates them. Like any policies, manipulation needs to be prevented and the policies are sensitive information that should be protected from being revealed.

Attack Malicious administrator

A malicious administrator accesses to the repository and discloses/changes the trust policies.

Existing Mitigation External monitoring and logging mechanisms to track the administrator's activities. These mechanisms should be external to the Trust-PDP in order to avoid their manipulation performed by the administrator.

Attack Unauthorized access

A malicious agent gains access to the trust policy repository to disclose/change the trust policies.

Existing Mitigation Logging and monitoring mechanisms to track the access records and to detect illegal behaviours.

Existing Mitigation Use of authorization mechanisms to control the access to the trust policy repository.

Attack Man in the Middle or network eavesdropping

A malicious agent gains the access to the trust policies during the querying/updating pro- cess.

Existing Mitigation Use of secure channels for data transmissions (i.e. HTTPS).

B.29.3 Asset: Trust-PDP Evaluation Service

Threat 1 Trust-PDP service not available

A malicious agent makes the Trust-PDP unavailable for the intended users.

Attack Denial of Service (DOS) attack

A malicious agent or a collectiveness of malicious agents saturates the Trust-PDP evaluation service with a huge amount of requests.

Implemented Mitigation The existence of monitoring and logging mechanisms to trace sus- pect behaviours.

Existing Mitigation The utilization of a firewall for the input/output traffic filtering.

Existing Mitigation Geographically restrictions on access domain: the service is made avail- able only to well known locations where requests are expected from.

Threat 2 Unauthorized Access to the Trust PDP evaluation service

A malicious agent uses the Trust-PDP evaluation service, sending requests and obtaining responses to use for malevolent purposes.

Attack Brute Force or Password Dictionary

A malicious agent obtains the access performing a brute force attack (trying all the possible passwords) or a password dictionary attack (trying with the most likelihood passwords).

Existing Mitigation Mechanisms that press for the usage of strong and effective passwords.

Implemented Mitigation Logging and monitoring mechanisms to detect possible misbehaviours.

Implemented Mitigation Single Sign On (SSO) authorization mechanisms to automatically and safely generate strong and secure tokens.

Threat 3 Request/Response Modification

A malicious agent changes the request or the response in order to manipulate the results of the evaluation.

Attack Parameter Tampering or Man in the Middle.

A malicious agent gains the access to the messages exchanged during a request/response process and alters such messages in a malevolent way.

Existing Mitigation Data integrity check mechanisms to verify that a response is feasible for a given request.

Existing Mitigation Mechanisms to link the response message to its associated request message.

Existing Mitigation Use of secure channels for data transmissions (i.e. HTTPS)

B.30 T3-PEP-AI: Application-independent Policy Enforcement Point

B.30.1 Entry Points

i. SOAP web interface

ii. Administrative shell login

B.30.2 Asset: Built-in Policies

Threat Unauthorised Modification of Built-in Policies

Attack Attacker manages to replace the policy contents of a built-in policy

If an attacker gains access to the machine hosting the policies (which is not necessarily the same as the machine hosting the AIPEP) then maybe she can replace a built-in policy with one of her own making.

Implemented Mitigation Cryptographic Protection

For PERMIS policies this attack is defended against by encapsulating the policy in a (self signed) X.509 Attribute Certificate. The cryptographic signature on the X.509 AC prevents tampering with its contents.

Existing Mitigation File System Permissions

For other policy formats, in particular XACML policies for the Sun XACML PDP or for the trust PDP, no such cryptographic protection exists at the moment. File system permissions can give some protection: the policies should only be readable (and not even writeable) by the AI-PEP itself.

B.30.3 Asset: Configuration File

Threat Unauthorised Modification of Configuration File

Attack Attacker Modifies Configuration File

If an attacker gains access to the machine hosting the AI-PEP, then she may be able to modify the configuration file e.g. to load an additional policy or to remove a policy which would deny her access.

The configuration file also contains the roots of trust for signature verification, so the attacker might also able to add a PKC of her liking to as a root of trust.

Existing Mitigation File System Permissions

Use file system permissions to protect the configuration file from being changed. Configura- tion file should only be readable by account running the AI-PEP service.

Existing Mitigation Use Restricted Account

The AI-PEP service should be run under an account with very few permissions, e.g. without remote login capabilities.

B.30.4 Asset: Roots of Trust (PKCs) for Signature Verification

Threat Attacker Adds/Deletes/Replaces the PKCs used for Signature Verification

Attack Attacker Gains Access to Machine with PKCs and Modifies Them

Existing Mitigation File System Permissions

Existing Mitigation Use a Password Protected Trust Store

Keeping the PKCs in a password protected trust store requires the attacker to guess the password for the trust store (or otherwise break its security).

Existing Mitigation Use Restricted Account

B.30.5 Asset: System Coordinates Decision Making

Threat System Crashes

Attack An Attacker Crafts a Malicious Message in Order to Crash the System

An attacker might attempt to send an authorization request (or a request to validate some credentials) to is formed in such a way as to make the server crash.

Implemented Mitigation Use of Schema Checking

The system is built in such a way that only requests conforming to the schema ever reach the server. A SOAP message not conforming to the schema is discarded by the Axis2 SOAP layer around the actual server.

B.30.6 Asset: The Sticky Store

Threat Unauthorised Modification of Sticky Store

Since the sticky store holds the binding between resources and the policies applicable to them, modifying this store might get an attacker unauthorised access to resources.

Attack Attacker Modifies the Sticky Store by Gaining Access to the Machine Hosting the Sticky Store

Non existing Mitigation Use Proper Access Control to Sticky Store

The sticky store hasn't been fully implemented yet. A first version will be a simple in- memory implementation of the sticky store which is by definition hard to modify for an attacker. However, once a persistent implementation (e.g. by using a relational database) is used then proper access controls need to be in place to prevent unauthorised access to this persistent storage.

B.31 T3-POL-GUI: Graphical Policy Editor

B.31.1 Entry points

Graphical User Interface of the application

B.31.2 Asset: Information in Configuration File

Threat Credentials to Policy Repository are Leaked

Attack 1 Attacker Reads Configuration File

Existing Mitigation File System Permissions

Non existing Mitigation Don't Store Secrets in the Configuration File

Attack 2 Attacker Sniffs Network Communication

Existing Mitigation Use SSL/TLS for Communication between PE and Repository

B.31.3 Asset: Private Signing Key Used to Sign Policies

Threat Compromise of the signing key

Attack Attacker Gains Access to Machine Running PE and Obtains Signing Key

Implemented Mitigation Use a Password Protected Key Store for the Private Key

Implemented Mitigation Do Not Store Password in a File

B.32 T3-POL-CNL: Controlled Natural Language Policy Editor

This is the same application as T3-POL-GUI.

B.33 T3-POL-WIZ: Wizard Policy Editor

This is the same application as T3-POL-GUI.

B.34 T3-PORT-JBOSS: JBOSS portal framework

The JBoss portal is used to display some portlets that embed different applications of TAS³ and its partners. For example it is possible to choose the audit viewer-portlet (TAS³ -component) and a business process-portlet (later from a TAS³ -associate).

The applications itself run on the server of its provider. The JBoss portal only shows the view on the applications. Later on these portlets will be able to communicate with each other e.G. to exchange authentication information.

The JBoss server and the underlying application stack (apache, tomcat, java) is an open source product.

B.34.1 Entry points

Intended Entry points

i. WebGui to access the JBoss portal

ii. Idp to get user authentication

iii. Portlets (to show the information of the external applications)

Internal Entry points

i. Shell or root shell (or ssh) for administrative login

ii. Tomcat management interface

iii. JBoss portal management interfaces

B.34.2 Asset: user data (functional data) and user credentials (non-functional data)

Threat 1 catch of user data

Attack Man-in-the-Middle-attack

Sniffing and/or modifying the communication between the JBoss portal and the user or other TAS³ components. e.G. catching of passwords or user data.

Existing Mitigation end-to-end-encryption

End-to-end-encryption of the whole communication between the TAS³ -components, the user and the JBoss portal could prevent a Man-in-the-middle-attack.

Threat 2 Application Stack

To run JBoss or a fedora-repository several additional underlying components are needed. This is e.g. the operating system, ssh, apache, tomcat and the application (Jboss or fedora) itself.

Attack 1 Flaws in the software components itself

Flaws in the software components (e.G. buffer overflow) enable attackers to obtain more rights than they used to have.

Existing Mitigation Automatically installed updates prevent older versions and flaws

Attack 2 Misconfiguration, e.g. guestuser with administrative rights

Existing Mitigation continuous control and tests with security-tools

Attack 3 `easy/bad` passwords

Easy passwords e.g. "test" or "secure" can be hacked very easily. This can give an attacker the identity and the rights of the user.

Existing Mitigation: use of blacklists and password rules

```
Blacklists can be used to prevent trivial passwords and
strong password rules ensure secure passwords.
```

Attack 4 careless user management

Careless user management (e.G. expired users are not removed) allow users to have more rights than they should have.

Existing Mitigation strict and clear rules and processes for TAS³ partners and members Continuous checks by the administrators and clear and strict processes for internal user management can support the user management. Rules and processes should be part of the legal documents for TAS³ partnership / member - registration.

Threat 3 compromised other TAS³ -components

Attack 1 compromised idp

A compromised idp could concede wrong data and additional rights to an user.

Existing Mitigation ensure Trustworthiness

IdPs and other security-relevant components and partners have to be trustworthy and con- trolled internally and regularly

Attack 2 toxic portlets

Portlets could contain unwanted functionality (e.G. additional user request for user id and password that is locally stored –> password phishing) that could allow a Misuse of data.

Existing Mitigation mandatory previous checks

Portlets should to be checked mandatory before used in the context of TAS³. Also changes made to the portlets should be notified automatically.

Attack 3 DoS-attack

Due to Denial-of-Service-attacks a user could be redirected' to specific and perhaps modified servers and service providers.

Existing Mitigation Continuous monitoring of availability, continuous checks of log files

B.34.3 Asset: internal data (non-functional data)

Threat 1 catch of internal data

Attack Man-in-the-Middle-attack

Sniffing and/or modifying the communication between the JBoss portal and the adminstrators or other TAS³ components. e.G. catching of passwords or user data.

Existing Mitigation::end-to-end-encryption

End-to-end-encryption of the whole communication between the TAS³ -components, the user and the JBoss portal could prevent a Man-in-the-middle-attack.

Threat 2 Application Stack

To run JBoss or a fedora-repository several additional underlying components are needed. This is e.g. the operating system, ssh, apache, tomcat, and the application (Jboss/fedora) itself.

Attack 1 Flaws in the software components itself

Flaws in the software components (e.G. buffer overflow) enable attackers to obtain more ac- cess the server at system level..

Existing Mitigation Automatically installed updates prevent older versions and flaws

Attack 2 Misconfiguration, e.G. guestuser with administrative rights

Existing Mitigation continuous control and tests with security-tools

Attack 3 easy/bad passwords

Easy passwords e.G. "test" or "secure" can be hacked very easily. This can give an attacker the identity and the rights of the user.

Existing Mitigation use of blacklists and password rules

Blacklists can be used to prevent trivial passwords and strong password rules ensure se- cure passwords. This should be fixed especially for administrators.

Attack 4 careless user management

Careless user management (e.G. expired users are not removed) allow users/admins to ac- cess the system even if they should not be allowed any more.

Existing Mitigation strict and clear rules and processes for TAS³ partners and members Continuous checks by the administrators and clear and strict processes for internal user management can support the user management. Rules and processes should be part of the legal documents for TAS³ partnership / member - registration. Especially when a admin is leaving the account has to be closed and the system should be checked for backdoors.

Threat 3 compromised other TAS³ -components

Attack 1 compromised idp

A compromised idp could concede wrong data and additional rights to an user.

Existing Mitigation ensure Trustworthiness

IdPs and other security-relevant components and partners have to be trustworthy and con- trolled internally and regularly.

Attack 2 toxic portlets

Portlets could have access to internal data and pass that to an external receiver.

Existing Mitigation mandatory previous checks

Portlets should to be checked mandatory before used in the context of TAS³. Also changes made to the portlets should be notified automatically.

Attack DoS-attack

Due to Denial-of-Service-attacks a user could be "redirected" to specific and perhaps modified servers and service providers.

Existing Mitigation Continuous monitoring of availability, continuous checks of log files

B.35 T3-REP-FEDORA: TAS³ reference repository

UNIKOLD

The Fedora repository is used as a reference repository. It stores user specific data and retrieves it upon confirmed and authorized (service) requests.

The repository itself runs on the server of its provider. The fedora repository and the underlying appli- cation stack (apache, tomcat, java) is an open source product. It is enriched by separately programmed modules for TAS³.

B.35.1 Entry points

Intended Entry points

- web service interface to access the repository data

Internal Entry points

i. Shell or root shell (or ssh) for administrative login

ii. Tomcat management interface

iii. fedora repository management interface

iv. Idp to get user authentication

v. PDP to verify the authorization

B.35.2 Asset: user data (functional data) and credentials (non-functional data)

4.31.2.1. Threat catch of user data

4.31.2.1.1. Attack Man-in-the-Middle-attack

Sniffing and/or modifying the communication between the fedora-server and other TAS³ components. e.G. catching of credentials or user data.

4.31.2.1.1.1. Existing Mitigation::end-to-end-encryption

End-to-end-encryption of the whole communication between the TAS³ - components, the user and the fedora-repository could prevent a Man-in-the-middle-attack.

4.31.2.2. Threat Application Stack

To run a fedora-repository several additional underlying components are needed. This is e.g. the oper- ating system, ssh, apache, tomcat, java, dbxml, database and the application (Jboss or fedora) itself.

4.31.2.2.1. Attack Flaws in the software components itself

Flaws in the software components (e.G. buffer overflow) enable attackers to obtain more rights than they used to have.

4.31.2.2.1.1. Existing Mitigation Automatically installed updates prevent older versions and flaws

4.31.2.2.2. Attack Misconfiguration

e.G. guestuser with administrative rights

4.31.2.2.2.1. Existing Mitigation continuous control and checks with security-tools

4.31.2.3. Threat compromised other TAS³ -components

4.31.2.3.1. Attack compromised PDP

A compromised PDP could concede wrong requests.

4.31.2.3.1.1. Existing Mitigation ensure Trustworthiness

PDPs and other security-relevant components and partners have to be trustworthy and controlled inter- nally and regularly

4.31.2.3.2. Attack DOS-attack

Due to Denial-of-Service-attacks a valid request could be blocked before it reaches the repository or the answer of the repository could be blocked.

4.31.2.3.2.1. Existing Mitigation Continuous monitoring of availability, continuous checks of log files

B.35.3 Asset: internal data (non-functional data)

Threat catch of internal data

4.31.3.1.1. Attack Man-in-the-Middle-attack

Sniffing and/or modifying the communication between the Fedora repository and the adminstrators or other TAS³ components. e.G. catching of passwords or user data could be a security problem.

4.31.3.1.1.1. Existing Mitigation::end-to-end-encryption

End-to-end-encryption of the whole communication between the TAS³ -components, the user and the

Fedora repository could prevent a Man-inthe-middle-attack.

4.31.3.2. Threat Application Stack

To run a fedora-repository several additional underlying components are needed. This is e.g. the oper- ating system, ssh, apache, tomcat, java, dbxml, a database and the fedora repository application itself.

4.31.3.2.1. Attack Flaws in the software components itself

Flaws in the software components (e.G. buffer overflow) enable attackers to obtain access the server at system level..

4.31.3.2.1.1. Existing Mitigation Automatically installed updates prevent older versions and flaws

4.31.3.2.2. Attack Misconfiguration

e.G. guestuser with administrative rights

4.31.3.2.2.1. Existing Mitigation continuous control and tests with security-tools

4.31.3.2.3. Attack easy/bad passwords

Easy passwords e.G. "test" or "secure" can be hacked very easily. This can give an attacker the identity and the rights of the user.

4.31.3.2.3.1. Existing Mitigation use of blacklists and password rules

Blacklists can be used to prevent trivial passwords and strong password rules ensure secure passwords. This should be fixed especially for administrators.

4.31.3.2.4. Attack careless user management

Careless user management (e.G. expired users are not removed) allow users/admins to access the system even if they should not be allowed any more..

4.31.3.2.4.1. Existing Mitigation strict and clear rules and processes for TAS³ partners and members

Continuous checks by the administrators and clear and strict processes for internal user management can support the user management. Rules and processes should be part of the legal documents for TAS³ partnership / member - registration. Especially when a admin is leaving the account has to be closed and the system should be checked for backdoors.

4.31.3.3. Threat compromised other TAS³ -components

4.31.3.3.1. Attack DOS-attack

Due to Denial-of-Service-attacks a user could be "redirected" to specific and perhaps modified servers and service providers.

Existing Mitigation Continuous monitoring of availability, continuous checks of log files

B.36 T3-REP-JFEDORA: JFEDORA Library for TAS³ Generic Data Format

B.36.1 Entry points

- Java (JAR) library interface

B.36.2 Asset: Message based on Generic Data Format

Threat Exploitation of messages

Attack Attackers exploit an application without leaving a trace

Existing Mitigation Identify malicious behavior.

Attack Attackers cover their tracks

Existing Mitigation Audit and log activity through all of the application tiers.

Existing Mitigation Secure access to log files

B.37 T3-SG-BASE: SOA Gateway Base System

B.37.1 Entry points

i. Internal Entry point: HTTP PUT/DELETE Method for specific files in configuration directory

ii. Internal Entry point: Shell login to machine for administration

iii. Intended Entry point: A SOAP web service call via the T3-SG-WSP component

B.37.2 Asset: Backend Legacy data

Threat SOA Gateway not available

Attack DOS Attack

Existing Mitigation Monitoring and Logging mechanisms

Existing Mitigation Firewalls utilization

Implemented Mitigation Reject requests not validated by T3-SG-WSP component.

Threat Unauthorized Access to the SOA Gateway services

Attack Read/update data using SOA Gateway services

Existing Mitigation Require use of HTTPS

Implemented Mitigation Reject requests not validated by T3-SG-WSP component.

Implemented Mitigation Ensure TAS³ security is always enabled on the SOA Gateway.

B.37.3 Asset: Server Configuration Files

Threat Gain SSH access to machine

Attack Once SSH access is granted, the attacker has access to sensitive data.

Implemented Mitigation Ensure credentials are secure. Use SSH public/private key ex- change.

B.38 T3-SG-WSP: SOA Gateway Web Service Provider

B.38.1 Entry points

i. Intended Entry Point: SOAP Web services with TAS³ Security

ii. Internal Entry point: IdP to get user authentication.

iii. Internal Entry point: PDP to verify authorization

B.38.2 Asset: Web services hosted by T3-SG- WSP component

Threat 1 Read/update using SOAP Web services

Attack Use the existing web services to read or update existing sensitive data.

Implemented Mitigation Ensure TAS³ security is always enabled on the SOA Gateway.

Implemented Mitigation Ensure that requests that do not pass the validation are rejected, and the access attempt logged.

Threat 2 Request/Response Modification

Attack Parameter Tampering, Man in the Middle

Implemented Mitigation Request/response encoding using ZXID.

Threat 3 Unauthorized Access to the SOA Gateway services

Attack Read/update data using SOA Gateway services

Implemented Mitigation Reject requests not validated by ZXID AZ API component.

Implemented Mitigation Enforce authorization based on the PDP response.

B.39 T3-SP-CVT: Europass CV Transcoding Web Service

B.39.1 Entry Points

i. Intended entry point: SOAP Back office Web services without TAS³ Security

ii. Internal entry point: Authentication key (password) to secure the requesting service.

B.39.2 Assets

i. Backend temporary personal data storage (optional, used for some transformation which needs to send back a link to a file instead of the CV data itself)

ii. Service/server configuration files

B.39.3 Threats

i. Denial of service

ii. Access to sensitive data in storage

iii. XML injection using Web services, XML

B.39.3.1 Attack

Use the existing web services for:

i. XML Injection Attack

ii. Buffer Overflow Attack.

Not existing Mitigation Validate incoming XML using the corresponding XML Schemas (valid for XML transformation based on Europass Cedefop XML schemas, Hr-XML Schemas, IMS ePortfolio (NL) schemas but not for Leap2a or hResume (i.e. Linkedin) transformations.

B.39.3.2 Attack

Use the existing web services for:

iii. Denial of Service Attack

Not existing Mitigation Be sure that optional support of requesting service ID is enabled (which provide a first basic level of security). Update the internal code to replace service ID support by a more secure service authentication token.

B.40 T3-SP-MATCHER: Job Profile Matching Service

B.40.1 Entry points

i. Intended Entry point: Web service interface for invoking service

B.40.2 Asset: Program logic that matches profiles of individuals to opportu- nities

Threat 1 Unauthorised invocation

Attack: Unauthorised call to WS interface

Not Implemented Mitigation In order to call the matcher a valid token will be needed. The token issued will come from the main TAS³ authorisation infrastructure and present the correct credentials to the service.

Threat 2 Overload of service creating failure in audit notifications

Attack Denial of service

Implemented Mitigation To prevent a denial of service attack calling services will be limited to specific to those which have been pre-authenticated by the TAS³ infrastructure. Specific terms of behavi

B.41 T3-STACK and T3-SSO-ZXID

B.41.1 Entry points

i. Shell or root shell (or ssh) administrative login

ii. TAS³ designed management interfaces (none yet)

iii. Product specific management interfaces

- Auto-CoT (fully automatic metadata exchange and trust establishment with anonymous third party SPs)

iv. Web GUI

v. SOAP web service

- SLO
- WSP

B.41.2 Data assets

i. Private keys of the service itself

ii. Circle-of-Trust database

iii. Service specific user data stores

iv. Session cache, including EPRs

B.41.3 Nonfunctional assets

i. Privacy preserving through avoidance of correlation handles

ii. User consent and control of data release

iii. Organizational control of data release

iv. User choice of WSP

v. Nonrepudiation

vi. Accountability

vii. Credible authentication of system entities

B.41.4 Attacks and mitigation

- Too numerous to describe exhaustively in one afternoon *** TBD
- Generally the data assets are protected using Unix filesystem permissions against shell and local Unix process access. This, of course, is of little value against root. Therefore deployment MUST use nonroot users for running all TAS³ related processes as well as for most administrative tasks.
- The TAS³ designed and product specific management interfaces follow good coding practises (e.g. check for ".." in path) to only allow designed access to the data assets.
- Web GUI is coded such that only authorized accesses are possible
- SOAP web service is coded such that only authorized accesses are possible
- Appropriate crypto layer (such as TLS) is applied in Web GUI, SOAP, and ssh entry points

B.42 T3-TPN-TB2: Trust Negotiation Module

B.42.1 Entry points

Credentials and Policy Negotiation (CPN) is a web service that can be called upon by any authorised TAS³ infrastructure component.

B.42.2 Assets

The user's attribute credentials and release policies.

B.42.3 Threats

Exposure of the user's attributes credentials and release policies without the user's consent.

B.42.4 Attacks

The user's attribute credentials are not exposed without his consent because the CPN agent enforces the user's release policies. Preventing unauthorised exposure is the very essence of the CPN agent functionality.

However, administrative action at the CPN server's site can also lead to unauthorised exposure. This is not prevented by technical means but should be ensured at the CPN agent's site by implementation of physical security coupled with appropriate personnel processes.

B.43 T3-TRU-CTM: Credential based trust service Component

B.43.1 Entry points

i. Internal Entry point: Shell or root shell

ii. Intended Entry point: CTM web service Interfaces

iii. Intended Entry point: Credentials Repository Interfaces

B.43.2 Asset: Credentials

Threat 1 Credentials Disclosure/Modification.

Credentials are sensitive information encapsulating roles and attributes referring to the users. For this reasons their disclosure or modification is a threat for the system.

Attack 1 Unauthorized access to the credentials repository

A malicious access to the credentials repository performed by the administrator or an unau- thorized user in order to disclose or modify the stored credentials.

Existing Mitigation The use of external monitoring and logging mechanisms to trace and detect suspect activities. These mechanisms should be external to avoid the manipulation of the records performed by malicious administrators.

Implemented Mitigation The usage of an authentication mechanism to prevent the access to the credentials repository performed by unknown or unauthorized agents.

Attack 2 Man in the middle, tampering

A malicious agent gains the access to the credentials intercepting the message exchanged during the querying/updating process involving the credentials repository.

Implemented Mitigation The credentials have a digital signature that makes difficult, for a malicious agent, to fake credentials.

Existing Mitigation The use of secure channels for data transmissions (i.e. HTTPS).

Threat 2 Unauthorized Access to the CTM service functionalities

The access to the CTM service functionalities itself grants the disclosure of credentials. The re- sponse of the service, indeed, brings the credentials.

Attack Brute Force or Password Dictionary

A malicious agent gains the access to the service and obtains the credentials performing a brute force or a password dictionary attack.

Implemented Mitigation Single Sign On (SSO) authorization mechanisms to automatically and safely generate strong and secure tokens.

Existing Mitigation Mechanisms that press for the usage of strong and effective passwords.

Implemented Mitigation Logging and monitoring mechanisms to detect possible misbehaviours.

B.43.3 Asset: CTM Web Service

Threat 1 CTM not available

A malicious agent makes the CTM web service unavailable for the intended users.

Attack Denial of Service (DOS) Attack

A malicious agent or a collectiveness of malicious agents saturates the CTM service with a huge amount of requests.

Implemented Mitigation The existence of monitoring and logging mechanisms to trace sus- pect behaviours.

Implemented Mitigation The CTM service is not registered in a public register. Only the Trust-PDP has a list of trusted CTM services.

Existing Mitigation The utilization of a firewall for the input output traffic filtering.

Threat 2 Request/Response Modification

A malicious agent gains the access to the request/response messages exchanged during a CTM service call process in order to modify the results of the service.

Attack Parameter Tampering, Man in the Middle

The request/response messages are modified eavesdropping the network used to exchange the messages.

Implemented Mitigation The credentials have a digital signature that makes difficult, for a malicious agent, to fake credentials.

Existing Mitigation Use of secure channels for data transmissions (i.e. HTTPS)

B.44 T3-TRU-KPI: Key Performance Indicators

B.44.1 Entry points

i. Internal Entry point: KPI Data Base

ii. Intended Entry Point: Online sources of KPIs

B.44.2 Asset: KPI Engine

Threat 1 Fake sources

Attack a fake host is simulating an online KPI source in order to provide garbage and fake data to the KPI engine

Existing Mitigation Authentication mechanism

Threat 2 KPI values modification

Attack man in the middle attack, interception and modification of the KPI messages sent by the KPI sources to the KPI engine

Existing Mitigation Securing the communication channel (SSL, TLS)

Existing Mitigation Signing the content of the messages

Threat 3 Privacy leaks

Attack Sniffing the traffic in order to guess the business objectives of a user or a company.

Existing Mitigation Securing the communication channel (SSL, TLS)

B.45 T3-TRU-RTM: Reputation Trust Management Service

B.45.1 Entry points

i. Intended Entry point: Shell or root shell

ii. Intended Entry point: RTM web service Interfaces for Trust PPD

iii. Intended Entry point: RTM web service Interfaces for the Feedback Service

iv. Intended Entry point: RTM web service Interfaces for feedback submitting

v. Internal Entry point: Feedback Repository Interfaces

B.45.2 Asset: Feedback

Threat Feedback Disclosure/Modification

Feedbacks are sensitive information because a user would like to feel free to release negative feed- back without the counterpart knew about that. For these reason the disclosure or the modification of feedback represents a threat for the system.

Attack Unauthorized Access to the feedback repository

A malicious access to the feedback repository performed by the administrator or an unauthorized user in order to disclose or modify the stored feedback.

Implemented Mitigation The usage of an authentication mechanism to prevent the access to the feedback repository performed by unknown or unauthorized agents.

Existing Mitigation The use of external monitoring and logging mechanisms to trace and detect suspect activities. These mechanisms should be external to avoid the manipulation of feedback performed by malicious administrators.

Attack Man in the Middle, tampering

A malicious agent gains the access to the feedback intercepting the message exchanged during the querying/updating process involving the feedback repository.

Existing Mitigation Use of secure channels for data transmissions (i.e. HTTPS)

B.45.3 Asset: RTM Web Service

Threat 1 RTM not available

A malicious agent makes the RTM web service unavailable for the intended users.

Attack Denial of Service (DOS) Attack

A malicious agent or a collectiveness of malicious agents saturates the RTM service with a huge amount of requests.

Implemented Mitigation The existence of monitoring and logging mechanisms to trace suspect behaviours.

Implemented Mitigation The RTM service is not registered in a public register. Only the Trust- PDP has a list of trusted RTM services.

Existing Mitigation The utilization of a firewall for the input output traffic filtering.

Threat 2 Unauthorized Access to the RTM functionalities

The access to the RTM service functionalities can reveal the reputation of an agent.

Attack Brute Force or Password Dictionary

A malicious agent gains the access to the service and obtains the credentials performing a brute force or a password dictionary attack.

Implemented Mitigation Single Sign On (SSO) authorization mechanisms to automatically and safely generate strong and secure tokens.

Existing Mitigation Mechanisms that press for the usage of strong and effective passwords.

Implemented Mitigation Logging and monitoring mechanisms to detect possible misbehaviours.

Threat 3 Request / Response Modification

A malicious agent modifies the request or the response changing the reputation values for malevolent purposes.

Attack Parameter Tampering, Man in the Middle

The request/response messages are modified eavesdropping the network used to exchange the messages.

Existing Mitigation Use of secure channels for data transmissions (i.e. HTTPS)

Annex C: User-Centricity in TAS³

C.1 Executive Summary

This document provides a final iteration of the agreed defining elements of user-centricity in TAS³. These elements have been identified based on existing deliverables, email discussions and meeting interaction. The subsequent sections list these elements and provide references to the deliverables that cover these aspects of user-centricity. This list has been continuously refined throughout the development of the project.

C.2 Defining elements of user-centricity in TAS³

C.2.1 The user's ability to express privacy preferences

Within TAS³ every data subject user will be provided with the opportunity to express his or her own privacy preferences with regards to at least the following aspects of the processing operations that take place within the TAS³ network:

- the categories of recipients of his or her personal data. The interface provided to the user shall be sufficiently granular to allow him or her both to identify categories of recipients, and also to exclude particular entities as potential recipients (e.g. to deny a particular physician future access to his/her PHR);

- what their processing capabilities shall be (e.g, read, write, edit, delete, ...) towards which data elements;

- for which context/purpose (e.g. pursuant to self-initiated job application but not for headhunting purposes; or when being referred to this doctor for treatment, etc);

- to formulate constraints (e.g. specify the time-period in which the processing operation is allowed to take place);

whether or not an operation is to be dependent on specific obligations (e.g. notification to audit and oversight committee).

The user's privacy preferences will be translated operationally within the TAS³ network in mainly three ways:

1. Either through a constrained delegation process (see deliverables D2.1 [TAS³ARCH], D7.1 [D7.1], D3.1 [AeGArch07]);

2. Under a policy-based approach(see deliverable D6.3 [D6.3]);

3. Or a combination of both 1 and 2.

In each of these instances the interface for the user will be the so-called 'dashboard' (see D2.1 [TAS³ARCH]), which may be under control of a business

process (see D3.1 [AeGArch07]). Under all three approaches, the user's privacy preferences will be translated into so-called 'sticky policies', which shall be attached to the data to ensure that all data recipients along the value chain are aware of usage restrictions (and to ensure that they are subsequently enforced at every stage; and passed on further if necessary).

In order to ensure proper enforcement, the consent by the data subject shall operate as a default requirement (policy condition) for any authorization decision by Policy Decision Points (PDPs) whenever appropriate. Other consent directives (e.g. restrictions with regards to subsequent use) shall be enforced by securely associating these instructions with the data as sticky policies.

The user has the possibility to express his/her privacy preferences in natural language, which will then be translated into machine-understandable format (RDF(S)/OWl) thanks to an ontology grounded in natural language (see deliverables D6.3 [D6.3], D2.2 [TAS3D22UPONTO] and D2.3 [D2.3]).

The ontology strengthens the user-centricity aspect since it allows use of partner-specific terminology in federated environments formed by multiple organizations, ensuring interoperability and openness in the TAS³ architecture.

Note 1: The user's expression of privacy preferences of course needs to take place within certain parameters. These parameters shall be clearly described in the initial privacy notice provided to the data subject during the intake/enrolment process. In particular, the user shall be notified of those aspects that he or she MUST subscribe to, such as processing operations, which may take place pursuant to legal obligations incumbent upon the user or the TAS³ network, or further processing for statistical purposes. The certain parameters influencing users' privacy preferences will change during participation in the TAS³ network dependent on the concrete process the user is involved in. E.g., the parameters are dependent on the purpose and the type of usage of the user's data, but are known at the start of the process to some degree (e.g. it is not always clear which concrete service providers will be called) and is concretized during the process execution. This will make it possible to predefine parts of the privacy preferences presenting the user with the known information (of the business process policy) and to concretize it during execution eventually (if wished by the user) by additional user interaction.

While pre-authorization is a possibility for relatively simple processes, more complex processes may require additional consent capture. After all, the user's general privacy preferences are intended to serve multiple purposes, and therefore cannot adapt to all situations or remove the need for additional consent in case of new or unanticipated uses of information (e.g. new service, new function involving different recipients). In order to accommodate the need for subsequent consent capture, a 'call-back' process shall be in place that alerts the individual to an unanticipated situation or 'out-of-policy' request for use of or access to information (see D2.1 [TAS³ARCH]). In other words, for most processes the user will exercise control prior to the moment that a service provider requests to undertake processing (pre-authorization), for others they will have to authorize the transaction at the moment that it is requested (user call-back).

C 2.2 The user's ability to manage his own partial identities

In addition to deciding which attributes he or she discloses to which service provider (and under which conditions), the user will also have the opportunity to choose which partial digital identities (identity providers or other authoritative sources for attribute information) he or she uses to provide these attributes.

In this regard the TAS³ approach is somewhat similar to the Microsoft Cardspace model; however, the TAS³ approach, called the Trusted Attribute Aggregation Service [Chadwick11] [TAS³ARCH] i.e.TAAS, (formerly CardSpace in the Cloud) is more advanced for four main reasons. First, the user has the ability to become actively involved in the management of the identifiers/ pseudonyms associated with his respective digital identities, and the correlations between them. Second, the TAS³ approach provides for an important functionality currently not provided by Cardspace, namely the ability to aggregate attributes across different partial identities to respond to a single request from a service provider, without compromising the privacy of the data subject with regards to the identifiers associated with these different partial identities. Thirdly, the TAAS interface filters the user's available identity attributes against the service provider's stated policy, and allows the user to select *individual attributes* to fulfill each of the SP's attribute requirements, unlike in Cardspace where the user has to select an entire information card from one IdP, which may contain many different attributes. Fourthly, the concept of Level of Assurance is built into TAAS, so that the SP is provided with an assurance level for each attribute assertion that it receives. In this way the SP can make trust decisions about the presented attributes.

Another advantage provided by TAS³ is the governance framework. The contract framework, coupled with the required polices, creates an ecosystem-wide binding of obligations.

D6.2.

C 2.3 The user's ability to express trust preferences and provide feedback

The user's ability to express trust preferences in TAS³ is accommodated by allowing the user to specify the 'trust rating' or 'trust score' [Böhm10] that is required for entities in order for them to be involved in processing operations involving his or her personal data. If the trust ranking of a chosen entity falls below the level specified by the user before the process is completed, the user will be notified and given the opportunity to terminate the process.

Example: A user may specify that head-hunters are authorized to access his e-Portfolio for placement purposes, but he trusts only head-hunters with a sufficiently high rating based on several trust factors. This condition then applies cumulatively along with the user's specified privacy preferences. So head-hunter X may initially have been authorized to access the user's e-Portfolio as far as the trust and privacy preferences were concerned (because the user has specified that his e-Portfolio may be accessed by head-hunters for placement purposes). If the trust rating of the head-hunter drops during the process (for example because other users give negative feedback on him), the head-hunter

fails to meet the required trust rating and is denied access. The user is then notified and may decide between choosing another service provider, changing the further processing logic, or terminating the process.

The user is also provided with a feedback mechanism, in which he or she can share experiences with regard to particular service providers. The resulting feedback in turn affects the `reputation' trust factor and thus also the overall 'trust rating' of the service provider in question.

See deliverable D5.4 [D5.4] (expression of trust preferences into policies), D5.2 [D5.2] (trust management based on user feedback), D5.3 [D5.3] (measuring different trust factors), D2.1 [TAS³ARCH] (subrole of auditor); upcoming deliverable D6.2 [NexofRA09] will address contractual issues related to reputation based service providers and any oversight processes/policies to help assure correctness and fairness; deliverables in WP 3 (especially D3.3 [D3.3] , D3.1 [AeGArch07]) provide the ability to apply and dynamically adapt trust policies and feedback in a process-specific context, this is handled in policies and supported by process-controlled user interactions; the final iteration of D9.2 [D9.2] will include user trust perception; which trust factors matter most to users in deciding their trust in service providers.

C 2.4 The user's ability to view his personal data

The user will have the ability to view his or her personal data through the application As part of the trust network each data holder shall be obliged to provide a service that allows the user to view his or her personal data. Additionally, the dashboard will provide the data subject with an overview of Service Providers that have accessed his or her personal data.

C 2.5 The user's ability to over-ride access controls

In some situations a user may be denied access to protected resources when he or she ought to have been, or needs to be, granted access. This could arise for a variety of reasons, such as emergencies, wrongly configured policies, or unexpected circumstances. Examples of each are: a patient is rushed to the accident and emergency department of the hospital and the treating doctor does not have access to the patient's medical records, or a new member of staff joins the organisation and is only granted partial rights to various resources so she cannot complete some of her assigned tasks, or a user is working late in the office to finish off an important bid proposal, and he needs to get access to the manager's financial figures in order to compute some project costs, but he is denied access. In all of these cases the user needs to over-ride the deny decision in order to gain access to the resource, as the time taken to apply for an official policy change might take days or certainly hours to complete, by which time it could be too late. TAS³ has implemented Break the Glass policies [Ferreira09], which allow defined classes of user to over-ride deny decisions when they determine themselves that there is an operational need to do so. Such instances do not go unnoticed however, because the TAS³ infrastructure allows obligations to be configured into the policy, such that these obligations will be enacted whenever a user decides to break the glass. These obligations could be to email the user's manager, or write the glass breakage to a secure tamperproof audit log. In all cases the user will need to justify his break the glass action at a later

date, since the system will have notified the event to the appropriate entity. Important points to note are: break the glass permission is not given to everyone – the security officer determines which class of user should have this permission – so the ability to break the glass is controlled by the authorisation policy; such break-the-glass privileged users are themselves empowered to decide whether they wish to break the glass or not – if they do not, there is no consequence, if they do, they will need to justify their decision at a later time (see D7.1 [D7.1]).

C 2.6 Enhanced transparency

TAS³ shall ensure that, as a rule, no operation upon personal data will be authorized within the TAS³ network without the prior consent of the data subject.

However, notice and consent typically only provide 'ex ante' transparency towards the data subject. The data subject usually has no or only limited means of verifying whether or not the data recipient has adhered to the asserted or negotiated policies.

TAS³ will enhance transparency towards the data subject by providing him or her with the opportunity to verify after the fact which actions upon his or her personal data have taken place. Due to the advanced level of security and accountability mechanisms applied throughout the TAS³ network, the user will be able to obtain a much higher degree of assurance that his or her privacy preferences have in fact been adhered to.

See deliverable D2.1 [TAS³ARCH] (dashboard)

There are two levels of audit facilities investigated in TAS³:

1. There is a common TAS³ audit log format and audit bus used by all components in a TAS³-compliant trust network. The components insert the log data into a central database using the audit bus and the audit service.
   The audit log viewer, which is integrated in the dashboard, retrieves the log messages relevant for a particular user from a database via the audit service . It also allows to sort and filter log messages, providing users with a quick overview. Because this log viewer exposes the bare log messages, it is fit for 'level 2' users. Inexperienced end users might require more support or a simpler view on the audit information.

2. The lifecycle for business processes pursued by WP3 (presented in D3.1 [AeGArch07]) envisages business processes designed in the form of graphical process models (BPMN diagrams), to which security properties are annotated. These annotated models are then translated into executable BPEL process that make use of the components of a secure business-process-management system (BPMS) embedded in a TAS³ trust network (the transformation and run-time components are described in D3.2 [D3.2]).

   WP3 is about to develop a tool that visualizes the execution of business-process instances, with a focus on security. The tool will be browser-based

and will show execution progress and data flow based on the BPMN diagram of a process. 'Focus on security' is twofold: first, the tool will visualize who has accessed which of someone's data at which time. Second, the tool will visualize security-specific properties, both on the type and the instance level. The tool will enable WP3 to carry out user studies based on the tool. The goal is to find out which security concepts are most important to users, and how they should be visualized. While the tool is planned as a prototype, it can showcase how to use the audit data generated by TAS³ business processes to provide a user-friendly audit facility. It is expected that the results will not be specific to business processes, but can be generalized to other applications and security features of TAS³.

3. The tool discussed in the prior item will also allow visualisation of the interplay of TAS³ security components to some degree, provided they have been modelled as BPMN diagrams. This can help end users understand how security in TAS³ works. As an example, think of the different web pages a user has to visit during single sign-on (SSO). When the data flow in the background is presented to the user visually, he/she will better understand the purpose of SSO.

References

[AAPML] Prateek Mishra, ed.: "AAPML: Attribute Authority Policy Markup Language", Working Draft 08, Nov. 28, 2006, Liberty Alliance / Oracle. http://www.oracle.com/technology/tech/standards/idm/igf/pdf/IGF-AAPML-spec-08.pdf

[AcctSvc] "Liberty ID-WSF Accounting Service Specification"

[AdvClient] "Liberty ID-WSF Advanced Client Technologies Overview", liberty-idwsf-adv-client- v1.0.pdf

[AeGArch07] "D3.1 Access-eGov Platform Architecture", Access-eGov consortium, Feb 12, 2007. http://www.accessegov.org/acegov/uploadedFiles/webfiles/cffile_4_3_07_3_25_17_PM.pdf, also http://www.accessegov.org/acegov/web/uk/index.jsp?id=50268

[Alberts01] Alberts, C. J., & Dorofee, A. J. (2001). OCTAVE Criteria Version 2.0. Tech. Report CMU/SEI-2001-TR-016. ESC-TR-2001-016.

[AMQP06] "AMQP: A General-Purpose Middleware Standard" (a.k.a Advanced Message Queueing Protocol), 2006.

[Anderson07] Anne Anderson: "Web Services Profile of XACML (WS-XACML) Version 1.0", Working Draft 10, OASIS XACML Technical Committee, 10 August 2007, avail- able at http://www.oasis-open.org/committees/download.php/24950/xacml-3.0-profile-webservices-v1-wd-10.zip

[Böhm10] Böhm, K. Etalle, S. Hartog, J.I. den, Hütter, C., Trabelsi, S., Trivellato, D. & Zannone, N. (2010). A flexible architecture for privacy-aware trust management. *Journal of Theoretical and Applied Electronic Commerce Research*, 5(2), 77-96.

[BraberEA07] Den Braber, F., Hogganvik, I., Lund, M. S., Stølen, K., & Vraalsen, F. (2007). Model- based security analysis in seven steps - a guided tour to the CORAS method. BT Tech- nology Journal, 25(1), pp. 101-117.

[CardSpace] InfoCard protocol (aka CardSpace) from Microsoft

[CARML] Phil Hunt and Prateek Mishra, eds.: "Liberty IGF Client Attribute Requirements Markup Language (CARML) Specification", Draft 1.0-12, Liberty Alliance, 2008. http://www.projectliberty.org/liberty/resource_center/specifications/igf_1_0_specs

[Castano07] Castano, S., Ferrara, A., Montanelli, S., Hess, G. N., and Bruno, S. (2007). State of the art on ontology coordination and matching. Report FP6-027538, BOEMIE.

[Chadwick08] David Chadwick: "Functional Components of Grid Service Provider Authorisation Ser- vice Middleware", Open Grid Forum, 17 September, 2008. (*** AuthzFunc0.7.doc)

[Chadwick09] David Chadwick: "FileSpace - An Alternative to CardSpace that supports Multi- ple Token Authorisation and Portability Between Device". Presented at IDtrust 2009, the 8th Symposium on Identity and Trust on the Internet, NIST, Gaithersberg, April 2009. Available from http://middleware.internet2.edu/idtrust/2009/papers/08-chadwick-filespace.pdf

[ChadwickEA09] David W Chadwick, Sassa Otenko and Tuan Anh Nguyen. "Adding Support to XACML for Multi-Domain User to User Dynamic Delegation of Authority". Interna- tional Journal of Information Security. Volume 8, Number 2 / April, 2009 pp 137-152. DOI 10.1007/s10207-008-0073-y

[ChadwickEA09b] David W Chadwick, Linying Su, Romain Laborde: "Use of XACML Request Context to Obtain an Authorisation Decision". GFD.159. 13 November 2009. Available from http://www.ogf.org/documents/GFD.159.pdf

[ChadwickSu09] David Chadwick, Linying Su: "Use of WS-TRUST and SAML to access a Credential Validation Service". GFD.157. 13 November 2009. Available from http://www.ogf.org/documents/GFD.157.pdf

[Chadwick11] David W Chadwick, George Inman, Kristy Siu. "Expression of Interest – Improving Identity Management on the Internet" Presented at W3C Identity in the Browser Workshop, Mountain View, May 2011. Available from http://www.w3.org/2011/identity-ws/papers/idbrowser2011_submission_12.pdf

[CogWalkthruWeb] http://www.cc.gatech.edu/classes/cs3302/documents/cog.walk.html

[CVS-SAML-WS-Trust] David Chadwick and Linying Su: "Use of WS-TRUST and SAML to access a Credential Validation Service", Open Grid Forum, 2008. (*** WS-TrustProfile0.8.doc)

[D2.3] "TAS³ Lower Common Ontology". TAS³ Deliverable D2.3, v.2.0, 17 Dec 2010.

[D3.2] "Open Source software and documentation implementing the design", TAS³ deliverable D3.2, v.10 (1.0), 29 June 2011.

[D3.3] "Integration with TAS³ trust applications of employment and eHealth processes", TAS³ deliverable D3.3, v.2.0, 30 Dec 2010.

[D5.2] "Behavioral Trust Management Engine", TAS³ deliverable D5.2, v.2.0, 30 June 2010.

[D5.3] "Novel Trust Metrics", TAS³ deliverable D5.3, v.1, 31 March 2010.

[D5.4] "Trust Tool Set", TAS³ deliverable D5.4, v3.0, 27 June 2011.

[D6.3] "Controlled Natural Language Policies". TAS³ Deliverable D6.3 v2.2. 25 June 2011.

[D7.1] "Design of Identity Management, Authentication and Authorization Infrastructure". TAS3 Deliverable D7.1 v3.0.1. 20 Dec 2010

[D9.2] "Pilot evaluation report", TAS³ deliverable D9.2, v.2.0, 24 June 2009.

[DahlEA07] Dahl, H., Hogganvik, I., & Stølen, K. (2007). Structured semantics for the CORAS security risk modelling language. Pre-proceedings of the 2nd International Workshop on Interoperability Solutions on Trust, Security, Policies and QoS for Enhanced Enterprise Systems (IS-TSPQ'07), (pp. 79-92).

[DesignPat] "Liberty ID-WSF Design Patterns", liberty-idwsf-dp-v1.0.pdf

[Dieng98] Dieng, R. and Hug, S. (1998). Comparison of "personal ontologies" represented through conceptual graphs. In Proceedings of the 13th European Conference on Artificial Intel- ligence (ECAI 98), pages 341-345, Brighton, UK.

[Disco2] Cahill, ed.: "Liberty ID-WSF Discovery service 2.0", liberty-idwsf-disco-svc-2.0-errata- v1.0.pdf from http://projectliberty.org/resource_center/

[Disco12] Liberty ID-WSF Discovery service 1.2 (liberty-idwsf-disco-svc-v1.2.pdf) [DST11] Liberty DST v1.1

[DST21] Sampo Kellomäki and Jukka Kainulainen, eds.: "Liberty Data Services Template 2.1", Liberty Alliance, 2007. liberty-idwsf-dst-v2.1.pdf from http://projectliberty.org/resource_center/specifications/

[DST20] Sampo Kellomäki and Jukka Kainulainen, eds.: "Liberty DST v2.0", Liberty Alliance, 2006.

[Enisa10] Inventory of Risk Management / Risk Assessment Methods. http://rm-inv.enisa.europa.eu/rm_ra_methods.html (fethced 25.6.2010)

[Ferreira09] Ana Ferreira, David W Chadwick, Pedro Farinha, Ricardo Correia., Gansen Zhao, Rui Chilro, Luis Antunes. "How to securely break into RBAC: the BTG-RBAC model", Annual Computer Security Applications Conference, Honolulu, Hawaii, December 2009. pp23-31.

[FF12] Liberty ID Federation Framework 1.2, Protocols and Schemas

[FMC03] Frank Keller, Siegfried Wendt: "FMC: An Approach Towards Architecture-Centric Sys- tem Development", Hasso Plattner Institute for Software Systems Engineering, 2003.

[FMCWeb] "Fundamental Modeling Concepts" http://fmc-modeling.org/

[GiraoSarma10] João Girão and Amardeo Sarma: "IDentity Engineered Architecture (IDEA)", in Towards the Future Internet, G.

Tselentis et al. (Eds.), IOS Press, 2010. (STAL9781607505396-0085.pdf)

[HafnerBreu09] Hafner & Breu: "Security Engineering for Service-Oriented Architectures", Springer, 2009.

[Hardt09] Dick Hardt and Yaron Goland: "Simple Web Token (SWT)", Version 0.9.5.1, Microsoft, Nov. 4, 2009 (SWT-v0.9.5.1.pdf)

[IAF] Russ Cutler, ed.: "Identity Assurance Framework", Liberty Al- liance, 2007. File: liberty-identity-assurance-framework-v1.0.pdf (from http://projectliberty.org/liberty/resource_center/papers)

[ICAMSAML2] Terry McBride and Dave Silver, eds.: "Federal Identity, Credentialing, and Access Man- agement Security Assertions Markup Language (SAML) 2.0 Profile", version 0.1.0 draft, Feb 17, 2010, Federal-ICAMSC-SAML-20-Profile-Draftv010-36529.pdf

[IDDAP] Sampo Kellomäki, ed.: "Liberty Identity based Directory Access Protocol", Liberty Al- liance, 2007.

[IDFF12] http://www.projectliberty.org/resources/specifications.php

[IDFF12meta] Peted Davis, ed., "Liberty Metadata Description and Discovery Specification", version 1.1, Liberty Alliance Project, 2004. (liberty-metadata-v1.1.pdf)

[IDPP] Sampo Kellomäki, ed.: "Liberty Personal Profile specification", Liberty Alliance, 2003. [IDWSF08] Conor Cahill et al.: "Liberty Alliance Web Services Framework: A Technical Overview", Liberty Alliance, 2008. File: idwsf-intro-v1.0.pdf (from http://projectliberty.org/liberty/resource_center/papers)

[IDWSF2IOP] Eric Tiffany, ed.:"Liberty ID-WSF 2.0 Interoperability Testing Procedures", Ver- sion Draft 1.0-01, 16. Aug. 2006. File: ID-WSF-2-0-TestProcedures-v1-01.pdf, from http://projectliberty.org/

[IDWSF2MRD] "Liberty ID-WSF 2.0 Marketing Requirements Document", Lib-erty Alliance, 2006. File: liberty-idwsf-2.0-mrd-v1.0.pdf (from http://projectliberty.org/liberty/strategic_initiatives/requirements/)

[IDWSF2Overview] "Liberty ID-WSF Architecture Overview", liberty-idwsf-overview-v2.0.pdf from http://projectliberty.org/resource_center/specifications

[IDWSF2SCR] "Liberty ID-WSF 2.0 Static Conformance Requirements", liberty-idwsf-2.0-scr-1.0- errata-v1.0.pdf

[IDWSFSecPriv] "Liberty ID-WSF Security & Privacy Overview", liberty-idwsf-security-privacy- overview-v1.0.pdf from http://projectliberty.org/resource_center/specifications/

[IGF] "An Overview of the Identity Governance Framework", Liberty Al- liance, 2007. File: overview-id-governance-framework-v1.0.pdf (from http://projectliberty.org/liberty/resource_center/papers)

[Interact2] "Liberty ID-WSF Interaction Service", liberty-idwsf-interaction-svc-2.0-errata-v1.0.pdf from http://projectliberty.org/resource_center/specifications/

[ISO27001] ISO standard 27001: http://www.iso.org

[Kellomaki08] Sampo Kellomäki: "Query Extension for SAML AuthnRequest", feature request to OA- SIS Security Services Technical Committee (SSTC), 2008. See OASIS SSTC mailing list archive.

[Levenshtein66] Levenshtein, V. I. (1966). Binary codes capable of correcting deletions, insertions and reversals. Soviet Physics Doklady, 10:707+.

[LibertyInterFed] Carolina Canales Valenzuela, Sampo Kellomäki, eds.: "Access to Identity- Enabled Web Services in Cross-Border, Inter-Federation Scenarios", Liberty Alliance, 2007. File: access-to-identity-enabled-services-in-inter-cot-scenarios-v1.0.pdf (from http://projectliberty.org/liberty/resource_center/papers)

[LibertyLegal] Victoria Sheckler, ed.: "Contractual Framework Outline for Circles of Trust", Liberty Alliance, 2007. File: Liberty Legal Frameworks.pdf (from http://projectliberty.org/liberty/resource_center/papers)

[LibertyXF] Sampo Kellomäki, ed.: "Cross Operation of Single Sign-On, Federation, and Identity Web Services Frameworks", Liberty Alliance, 2006.

[Madsen03] Paul Madsen: "WS-Trust: Interoperable Security for Web Services" Available from http://www.xml.com/pub/a/ws/2003/06/24/ws-trust.html

[Mbanaso09] U.M. Mbanaso, G.S. Cooper, David Chadwick, Anne Anderson: "Obligations of Trust for Privacy and Confidentiality in Distributed Transactions", Internet Research. Vol 19, No 2, 2009, pp. 153-173.

[Meier08] J.D. Meier: "Threats, Attacks, Vulnerabilities, and Countermeasures", 30.3.2008. http://shapingsoftware.com/2008/03/30/threats-attacks-vulnerabilities- and-countermeasures/

[Meier09] J.D. Meier: "Security Hot Spots", 9.3.2009. http://shapingsoftware.com/2009/03/09/security- hot-spots/

[Microsoft06] Microsoft Centre of Excellence. (2006). The Security Risk Management Guideline. Mi- crosoft Solutions for Security and Compliance.

[MS-MWBF] Microsoft Web Browser Federated Sign-On Protocol Specification, 20080207, http://msdn2.microsoft.com/en-us/library/cc236471.aspx

[Nagios] "System, Network, and Application Monitor", the latest incarnation of the Satan and Net Saint saga, http://www.nagios.org/

[NexofRA09] "Deliverable D6.2 RA Model V2.0", All NEXOF-RA Partners, NESSI Strategic Project and External Contributors, 2009.

[NIST-SP800-30] Gary Stoneburner, Alice Goguen, and Alexis Feringa: "Risk Management Guide for Information Technology Systems", Recommendations of the National Institute of Standards and Technology, NIST, 2002. http://csrc.nist.gov/publications/nistpubs/800-30/sp800-30.pdf

[NIST-SP800-42] John Wack, Miles Tracy and Murugiah Souppaya: "Guideline Network Security", Recommendations of the National Institute of Standards and Technology, NIST, 2002. http://csrc.nist.gov/publications/nistpubs/800-30-42/sp800-42.pdf

[NIST-SP800-63] William E. Burr, Donna F. Dodson, Ray A. Perlner, W. Timothy Polk, Sarbari Gupta, Emad A. Nabbus: "Electronic Authentication Guideline", Recommendations of the Na- tional Institute of Standards and Technology, NIST Special Publication 800-63-1, Feb 2008. http://csrc.nist.gov/publications/nistpubs/

[OAUTH] http://oauth.net/

[ODMF] P. De Baer, Y. Tang and R. Meersman, “An ontology-based data matching framework: use case competency-based HRM”, in Proc. of the 4th Int. OntoContent’09 Workshop, On the Move to Meaningful Internet Systems, LNCS, pp. 514-523, Portugal, 2009.

[OpenID] http://openid.net/

[OWL-S-Web] David Martin, ed.: "OWL-S: Semantic Markup for Web Services", W3C, 22. Nov, 2004. http://www.w3.org/Submission/OWL-S/

[PCI08] "Payment Card Industry Data Security Standard", Version 1.2, Oct 2008, PCI Security Standards Council. Document pci_dss_v1-2.pdf from https://www.pcisecuritystandards.org/security_standards/pci_dss.shtml

[Peeters09] Roel Peeters, Koen Simoens, Danny De Cock, and Bart Preneel: "Cross-Context Dele- gation through Identity Federation", KUL 2009 (To be published?)

[PeopleSvc] "Liberty ID-WSF People Service Specification", liberty-idwsf-people-service-1.0- errata-v1.0.pdf from http://projectliberty.org/resource_center/specifications/

[PERMIS] D.W.Chadwick and A. Otenko: "The PERMIS X.509 Role Based Privilege Management Infrastructure". Future Generation Computer Systems, Vol 19, Issue 2, Feb 2003. pp 277-289

[RFC1157] J. Case et al.: " A Simple Network Management Protocol (SNMP)", RFC 1157, 1990. [RFC1950] P. Deutcsh, J-L. Gailly: "ZLIB Compressed

Data Format Specification version 3.3", Aladdin Enterprises, Info-ZIP, May 1996

[RFC1951] P. Deutcsh: "DEFLATE Compressed Data Format Specification version 1.3", Aladdin Enterprises, May 1996

[RFC1952] P. Deutcsh: "GZIP file format specification version 4.3", Aladdin Enterprises, May 1996 [RFC2119] S. Bradner, ed.: "Key words for use in RFCs to Indicate Requirement Levels", Harvard University, 1997.

[RFC2138] C. Rigney et al.: "Remote Authentication Dial In User Service (RADIUS)", RFC 2138, April 1997.

[RFC2139] C. Rigney: "RADIUS Accounting", RFC 2139, April 1997.

[RFC2246] T. Dierks and C. Allen: "The TLS Protocol Version 1.0", RFC 2246, January 1999. [RFC2251] M. Wahl, T. Howes, S. Kille: "Lightweight Directory Access Protocol (v3)", RFC 2251, December 1997.

[RFC2256] Wahl, M., "A Summary of the X.500(96) User Schema for use with LDAPv3", RFC 2256, December 1997.

[RFC2560] Myers et al., "X.509 Internet Public Key Infrastructure Online Certificate Status Protocol - OCSP", RFC 2560, June 1999.

[RFC2798] M. Smith: "Definition of the inetOrgPerson LDAP Object Class", Netscape Communi- cations, RFC 2798, April 2000.

[RFC3548] S. Josefsson, ed.: "The Base16, Base32, and Base64 Data Encodings", July 2003. (Sec- tion 4 describes Safebase64)

[RFC3588] P. Calhoun et al.: "Diameter Base Protocol", RFC 3588, September 2003.

[RFC3768] R. Hinden, ed.: "Virtual Router Redundancy Protocol (VRRP)", RFC 3768, April 2004. [SAML2LOA] OASIS. "Level of Assurance Authentication Context Profiles for SAML 2.0" Working Draft 01. 01 July 2008 [SAML11core] SAML 1.1 Core, OASIS, 2003

[SAML11bind] "Bindings and Profiles for the OASIS Security Assertion Markup Language (SAML) V1.1", Oasis Standard, 2.9.2003, oasis-sstc-saml-bindings-1.1

[SAML2core] "Assertions and Protocols for the OASIS Security Assertion Markup Language (SAML) V2.0", Oasis Standard, 15.3.2005, saml-core-2.0-os

[SAML2prof] "Profiles for the OASIS Security Assertion Markup Language (SAML) V2.0", Oasis Standard, 15.3.2005, saml-profiles-2.0-os

[SAML2profErrata] OASIS. "Profiles for the OASIS Security Assertion Markup Language (SAML) V2.0 - Errata Composite Working Draft", 12 February 2006

[SAML2bind] "Bindings for the OASIS Security Assertion Markup Language (SAML) V2.0", Oasis Standard, 15.3.2005, saml-bindings-2.0-os

[SAML2context] "Authentication Context for the OASIS Security Assertion Markup Language (SAML) V2.0", Oasis Standard, 15.3.2005, saml-authn-context-2.0-os

[SAML2meta] Cantor, Moreh, Philpott, Maler, eds., "Metadata for the OASIS Security Assertion Markup Language (SAML) V2.0", Oasis Standard, 15.3.2005, saml-metadata-2.0-os

[SAML2security] "Security and Privacy Considerations for the OASIS Security Assertion Markup Lan- guage (SAML) V2.0", Oasis Standard, 15.3.2005, saml-sec-consider-2.0-os

[SAML2conf] "Conformance Requirements for the OASIS Security Assertion Markup Language (SAML) V2.0", Oasis Standard, 15.3.2005, saml-conformance-2.0-os

[SAML2glossary] "Glossary for the OASIS Security Assertion Markup Language (SAML) V2.0", Oasis Standard, 15.3.2005, saml-glossary-2.0-os

[SAML2SimpleSign] "SAML 2.0 POST Simple Sign Binding", OASIS, 2008.

[Schema1-2] Henry S. Thompson et al. (eds): XML Schema Part 1: Structures, 2nd Ed., WSC Rec- ommendation, 28. Oct. 2004, http://www.w3.org/2002/XMLSchema

[SecMech2] "Liberty ID-WSF 2.0 Security Mechanisms", liberty-idwsf-security-mechanisms-core-2.0-errata-v1.0.pdf from http://projectliberty.org/resource_center/specifications

[SecureBPMSArch2011] Jens Müller and Klemens Böhm, "The Architecture of a Secure Business-Process-Management System in Service-Oriented Environments", in: Proceedings of the 9th IEEE European Conference on Web Services (ECOWS 2011), Lugano, Switzerland, September 2011 (to appear)

[Shibboleth] http://shibboleth.internet2.edu/shibboleth-documents.html

[SHPS] Conor Cahill, et al.: "Service Hosting and Proxying Service Specification", Liberty Al- liance Project, 15. Dec. 2006.

[Siemens10] Cram Methods http://www.cramm.com (fetched in 25.6.2010)

[SOAPAuthn2] "Liberty ID-WSF Authentication, Single Sign-On, and Identity Mapping Services Specification", liberty-idwsf-authn-svc-2.0-errata-v1.0.pdf from http://projectliberty.org/resource_center/specifications/

[SOAPBinding2] "Liberty ID-WSF SOAP Binding Specification", liberty-idwsf-soap-binding-2.0-errata- v1.0.pdf from http://projectliberty.org/resource_center/specifications

[SOX02] "Sarbanes-Oxley Act of 2002", Public Law 107-204, United States, 2002. http://frwebgate.access.gpo.gov/cgi-bin/getdoc.cgi?dbname=107_cong_public_laws&docid=f:publ204.107

[SUBS2] "Liberty ID-WSF Subscriptions and Notifications Specification", liberty-idwsf-subs- v1.0.pdf from http://projectliberty.org/resource_center/specifications/

[SwiderskiSnyder04] Frank Swiderski and Window Snyder. Threat Modeling. Microsoft Press, 2004. [SWIG] Simplified Interface and Wrapper Generator by Dave Beazley. www.swig.org [TAS3ARCH] Sampo Kellomäki, ed.: "TAS3 Architecture", TAS3 Consortium, 2009. Document: tas3-arch-vXX.pdf, also deliverable D2.1, document: tas3-deliv-2_1-arch-v17_2.pdf

[TAS³ARCH] "TAS³ Architecture", TAS³ Consortium, TAS³ Deliverable D2.1, v24, 10 July 2011. Document: TAS³- arch-v24.pdf

[TAS3BIZ] Luk Vervenne, ed.: "TAS3 Business Model", TAS³ Consortium, 2009.

[TAS3COMPLIANCE] Sampo Kellomäki, ed.: "TAS3 Compliance Requirements", TAS3 Consortium, 2009. Document: tas3-compliance-vXX.pdf

[TAS3CONSOAGMT] "TAS3 Consortium Agreement", TAS³ Consortium, 2008. (Not publicly avail- able.)

[TAS3D12DESIGNRAR] David Chadwick (Kent), Seda Gürses (KUL), eds.: "Require- ments Assessment Report", TAS3 Consortium, 20090102. Document: TAS3_D1p2_Requirements_Assesment_Report_1_V1p0.pdf

[TAS3D14DESIGNREQ] Gilles Montagnon (SAP), ed.: "Design Requirements", TAS3 Consortium, 20081221. Document: TAS3_D1p4_Design_Requirements_1_V2p0.pdf

[TAS3D22UPONTO] Quentin Reul (VUB), ed.: "Common Upper Ontologies", TAS3 Consortium, Deliverable D2.2, 7.5.2009. Document: D2.2_ver1.7.pdf

[TAS3D41ID] Sampo Kellomäki, ed.: "Identifier and Discovery Function", TAS3 Deliverable 4.1, 2009. Document: tas3-disco-v01.pdf

[TAS3D42Repo] David Chadwick, ed.: "Specification of information containers and authentic reposito- ries", TAS3 Deliverable 4.2, 2009.

[TAS3D62Contract] Joseph Alhadef, Brendan Van Alsenoy: "Contractual Framework", v3.0, TAS3 De- liverable D6.1, December 2009.

[TAS3D71IdMAnAz] TAS3 Deliverable 7.1. "Design of Identity Management, Authentication and Au- thorization Infrastructure" 3 Jan 2009.

[TAS3D81RepoSW] "Software Documentation System: Repository Services", UniKOLD, TAS3 Deliv- erable 8.1, 2009.

[TAS3D82BackOffice] "Back Office Services with Documentation", TAS3 Consortium, 2009. [TAS3D83CliSW] "TAS3 Client Software with User Guide", TAS3 Consortium, 2009. [TAS3D91PilotUC] "Pilot Use Cases", Deliverable D9.1, TAS3 Consortium, 2009.

[TAS3DOW] "TAS3 Description of Work", TAS3 Consortium, 2008. (Not publicly available.) File: TAS3_DescriptionOfWork.DoW.technical.annex.final.version.20071030.pdf

[TAS3GLOS] Quentin Reul (VUB), ed.: "TAS3 Glossary", TAS3 Consortium, 2009. Document: tas3- glossary-vXX.pdf

[TAS3PROTO] Sampo Kellomäki, ed.: "TAS3 Protocols and Concrete Architecture", TAS3 Consortium, 2009. Document: tas3-proto-vXX.pdf

[TAS3RISK] Magalie Seguran, ed.: "TAS3 Risk Assessment", TAS3 Consortium, 2010. Document: tas3-risk-vXX.pdf

[TAS3TECHQUIZ] Sampo Kellomäki, ed.: "TAS3 Technical Self-Assessment Questionnaire", TAS3 Consortium, 2010. Document: tas3-tech-quiz-vXX.pdf

[TAS3THREAT] Sampo Kellomäki, ed.: "TAS3 Threat Analysis", TAS3 Consortium, 2009. Document: tas3-threats-vXX.pdf

[TAS3USERCENT] Gilles Montagnon, ed.: "TAS3 User Centricity Report", TAS3 Consortium, 2010. Document: tas3-user-cent-vXX.pdf

[TAS3WP] "TAS3 Architecture White Paper", TAS3 Consortium, 2009 (as of 20090324 to be published).

[Tom09] Allen Tom, et al.: "OAuth Web Resource Authorization Profiles (OAuth WRAP)", Ver- sion 0.9.7.2, Google, Microsoft, and Yahoo, Nov. 5, 2009 (WRAP-v0.9.7.2.pdf)

[TrustBuilder2] Adam J. Lee, Marianne Winslett and Kenneth J. Perano: "TrustBuilder2: A Reconfigurable Framework for Trust Negotiation", IFIP Trust Management Conference, June 2009. In IFIP Advances in Information and Communication Technology, Trust Management III, 176-195. Springer Boston, 2009.

[UML2] http://www.sparxsystems.com.au/resources/uml2_tutorial/

[UNDP07] "e-Government Interoperability Guide", United Nations Development Programme, 2007. http://www.apdip.net/projects/gif/GIF-Guide.pdf

[UniPro] Winslett, Ting Yu and Marianne. "A Unified Scheme for Resource Protection in Automated Trust Negotiation." IEEE Symposium Security and Privacy. IEEE, 2003.

[VenturiEA08] V. Venturi, et al.: "Use of SAML to retrieve Authorization Credentials", Open Grid Forum, 2008. (*** Attribute PullProfilev1.5.doc; CVS related)

[Wharton94] C. Wharton et al. "The cognitive walkthrough method: a practitioner's guide" in J. Nielsen & R. Mack "Usability Inspection Methods" pp. 105-140, Wiley, 1994. [WSML-Web] "Web Services Modelling Language" http://www.wsmo.org/wsml/

[WSMO05] D. Roman, U. Keller, H. Lausen, J. de Bruijn, R. Lara, M. Stollberg, A. Polleres, C.

Feier, C. Bussler, and D. Fensel (2005). "Web Service Modeling Ontology". In Applied Ontology 1, pages 77-106.

[WSMO-Web] "Web Services Modelling Ontology" http://www.wsmo.org/

[WSPolicy] Bajaj et al.: "Web Services Policy Framework (WS-Policy) and Web Ser- vices Policy Attachment (WS-PolicyAttachment)", W3C, March 2006. http://schemas.xmlsoap.org/ws/2004/09/policy/

[WSTrust] "WS-Trust 1.3", CD 6, OASIS, Sept 2006. (*** WS-Trust, STS, etc.) [X520] ITU-T Rec. X.520, "The Directory: Selected Attribute Types", 1996. [X521] ITU-T Rec. X.521, "The Directory: Selected Object Classes", 1996.

[XACML2] "eXtensible Access Control Markup Language (XACML)" v2.0, OASIS Standard, February 2005. From http://www.oasis-open.org/committees/tc_home.php?wg_abbrev=xacml

[XACML2SAMLold] "SAML 2.0 Profile of XACML, Version 2, Working Draft 5", 19 July 2007, OA- SIS. (*** instead of "SAML 2.0 profile of XACML v2.0, ERRATA, Working Draft 01, 17 November 2005" which is the version that the profile is currently based on; XACML-ContextProfile1.1.doc from Open Grid Forum - OGF)

[XACML2SAML] "SAML 2.0 Profile of XACML, Version 2, Committee Draft", 16 April 2009 [XML] http://www.w3.org/TR/REC-xml

[XML-C14N] XML Canonicalization (non-exclusive), http://www.w3.org/TR/2001/REC-xml-c14n-20010315; J. Boyer: "Canonical XML Version 1.0", W3C Recommendation, 15.3.2001, http://www.w3.org/TR/xml-c14n, RFC3076

[XML-EXC-C14N] Exclusive XML Canonicalization, http://www.w3.org/TR/xml-exc-c14n/ [XMLDSIG] "XML-Signature Syntax and Processing", W3C Recommendation, 12.2.2002, http://www.w3.org/TR/xmldsig-core, RFC3275

[XMLENC] "XML Encryption Syntax and Processing", W3C Recommendation, 10.12.2002, http://www.w3.org/TR/xmlenc-core

[XPATH99] James Clark and Steve DeRose, eds. "XML Path Language (XPath) Version 1.0", W3C Recommendation 16 November 1999. From: http://www.w3.org/TR/xpath

[ZXIDREADME] Sampo Kellomäki: "README.zxid" file from zxid.org, 2009.

Document ID tas3-deliv-2_1-arch-v23.pdf

URL path https://portal.tas3.eu/arch/review/tas3-deliv-2_1-arch-v23.pdf