The Service Engineering Area: An overview of its current state and a vision of its future

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Version: 2.0

Date: January 2006

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1. INTRODUCTION

This report has been produced by the Software technologies unit of the European Commission as part of an ongoing activity to refine research priorities. Focused on the area of Service engineering, it is intended to support discussions with the community in order to identify key research challenges in service engineering and important areas for FP7.

This second public version is based on the results of a workshop held in Brussels in November 2005 on Future Service Engineering (http://cordis.europa.eu/ist/st/fse_101105.htm), where the participants refined the first version of this document. We want to thank all participants to this meeting for their useful contribution.

The report is structured around the four main categories of challenges identified at the workshop:

(1) How should we develop services?

(2) How to provide intelligent services that leave the user in control?

(3) How can we electronically represent all of the things that exist in a real world service?

(4) How can different types of services (web services, grid, p2p, agents) interoperate with each other and also work on different kinds of networks (internet, p2p, home networks)

This document examines how each project in the area of service engineering aims to solve part of these challenges. The idea is that this content is useful for the existing projects to understand what they can learn from each other and where they can cooperate. For future projects this information can be used to quickly understand what the current projects are doing and how they might re-use their results.

Comments are welcome from any interested parties and will be used in the preparation of future versions of this document. The aim is that this report will finally evolve to an overview of the service engineering research done during Framework Programme 6.
2. **What are Services?**

The word “service” means different things to different people. While a general definition is that a service is useful labour that does not produce a tangible commodity, within the context of this report we are interested in **services that are mainly delivered by software**.

A useful definition from the ICSOC 2005\(^1\) conference is that services are autonomous, platform-independent computational elements that can be described, published, discovered, orchestrated and programmed using standard protocols for the purpose of building networks of collaborating applications distributed within and across organizational boundaries.

The unit D3 “Software Technologies” is stimulating research projects that prepare the ground for new types of end-user service economies where innovative players (emerging service SMEs, telecom operators, even individuals) have the software infrastructure and tools to easily create and deploy new types of services. In order to offer unprecedented opportunities for European society, research should result in the development of services that are

- simple to use with a high perceived value
- adaptive to the situation and environment
- providing intelligent support while leaving the user in control
- provided transparently through different infrastructures and devices.

### 2.1. What is different when using services?

Service engineering builds on trends from software engineering, specifically the trend towards greater encapsulation and the trend towards later binding. The trend to greater encapsulation can be followed from monolithic programs, through structured, object oriented and component based software engineering and into service engineering, with increasing importance given to a clear interface specification and to hiding the details of implementation. The trend towards later binding runs from statically linked programs through to composite services which may be dynamically re-composed at run-time.

The particular challenges of service engineering – as distinct from software engineering – include how to describe, to discover, to compose and to monitor services. There is much industrial and research activity in each of these areas, which are discussed further below in section 6.

Three new roles are introduced when talking about services – the provider, consumer and broker. A provider makes a service available, and a consumer uses it without worrying about its internal details. Consumers can at the same time be providers, when they make available a composite service based on already existing services. The role of the broker is to help consumers find the services they need.

Ideally, value networks of co-operating services will start appearing that can offer personalised functionality to individuals or organisations. These value networks can be

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\(^1\) [http://www.icsoc.org/](http://www.icsoc.org/)
created in advance by a provider, but also “on the fly” in order to respond to very specific needs.

The basic assumption for all this to happen is that the interface of a service is specified properly. The interface is the “contract” between the provider and consumer, and should contain all information that enables a consumer to depend on the service and for the provider not to be blamed for any malfunctioning. With the current state of the art technology (web services) it is only possible to provide syntactical descriptions. Research is focusing on extending this with semantics, making it possible for consumers to understand the meaning of the offered functionality and to understand how the service can be properly used. Other properties of the service need to be described as well, so that a consumer can decide whether he/she can depend on that service and what costs are associated with using it.

Semantic matching will also be useful when designing new services. Of course, new services may be built from scratch, not using already existing services; then their development does not differ significantly from other software, and the usual software engineering techniques may be used. However, it seems much more beneficial to develop not from scratch, but to base new services on a combination of already existing services. In order to do so, the service designer needs first to be able to discover individual or combinations of services that completely or partially satisfy his requirements, for which again semantic matching is needed.

In order to develop value networks of services it is necessary to “compose” or put together the services. Currently this can be done manually by a tedious process based on the syntactical descriptions of the service interfaces. Usually, only services developed within one company are composed. The risk of relying on services provided by a third party is in general still too high. The real potential of software services will be available when the step from this static intra-company composition to dynamic, inter-company composition is made. Only then will it be possible to create an on the fly value network of services that can respond to very personal needs of an individual or organisation.

2.2. How can we categorise services?

We can categorise software based services according to their functional use:

- **Context adaptive and intelligent user services:** These are “ambient intelligence” type of services providing users the ability to access the services they need, anywhere from any device. This category also includes Location-based services (LBS), a family of services that depend on the knowledge of the geographic location of mobile stations.

- **Information services:** services that provide (personalised) information, for instance by comparing, classifying, or otherwise adding value to separate information sources.

- **Intermediary services:** services that help in finding appropriate services, for instance search services.

Another useful classification is made according to the technical protocols or business model used:
• **Web services:** A Web service is a software system designed to support interoperable machine-to-machine interaction over a network. It has an interface described in a machine-processable format (specifically WSDL). Other systems interact with the Web service in a manner prescribed by its description using SOAP-messages, typically conveyed using HTTP with an XML serialization in conjunction with other Web-related standards.²

• **P2P services:** P2P services are services which are offered by peers in a p2p network to other peers of that network. P2P services provide functionality such as resource sharing, messaging, etc. Interactions among peers in a p2p network don't have to be direct; communication between two peers in a p2p network may involve other intermediate peers.

• **Grid services:** Grid is a type of parallel and distributed system that enables the sharing, selection, and aggregation of geographically distributed resources dynamically at runtime depending on their availability, capability, performance, cost, and users' quality-of-service requirements. Grids aim at exploiting synergies that result from cooperation - ability to share and aggregate distributed computational capabilities and deliver them as service.³

3. **IMPORTANCE OF THE SERVICE ENGINEERING AREA**

One of the important and visible current trends is towards service oriented architecture – SOA. This specifies a set of loosely coupled services - whose interfaces are published, discovered and invoked over the net - along with their interactions. Communication between the various components in SOA can involve either simple data passing or it could involve two or more services coordinating some activity.

An important driver for service-oriented architectures is an increasing gulf between what companies require and IT is able to deliver (“the business-IT gap”). Business models are changing, with decision-making becoming more distributed and the emergence of “ecosystems” of co-operating partners and customers. This requires a new IT architecture, one that is more flexible and adaptable, but also meets users’ requirements for lower total cost of ownership.⁴

The convergence between the internet, telecommunications and media also benefit from service engineering. Web services enable a mobile terminal to be a full member in a service oriented world. They also allow mobile applications to share data and utilize external resources over the internet, regardless of their platforms or operating systems and without differentiating between devices used to access them.⁴

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³ [http://www.gridcomputing.com/gridfaq.html](http://www.gridcomputing.com/gridfaq.html)

Our unit's work on the engineering of software-enabled services aims to prepare the ground for new types of end-user service economies where innovative players (including emerging service SMEs, but also telecom operators, or even individuals) have the software infrastructure and tools to easily create and deploy new types of e-services. This will create new opportunities for the European software industry and bring benefits to European citizens.

Examples of such opportunities are:

- SMEs can integrate with larger supply chains.
- Large companies with multiple business units can quickly react to market changes by creating value through co-operation between the business units.
- Small businesses or even individuals can, without big investments, turn their special ability into a service which might be consumed by other individuals or companies. They do not need to create all the functionality of the service, but they can add their idea to an already existing base of services, in order to further specialise a service.
- Mobile users can be connected to rich, context-dependent data and applications to for instance query delivery status (in a business to business scenario), or to check work orders through an intranet application (in case of field workers of a certain enterprise).

An important part of the software market has been traditionally dominated by companies from the USA. Service engineering brings new opportunities for Europe to play a leading role. This is also recognised by the Technology Platform NESSI. Promoted by thirteen major European ICT corporations, totalling almost a million jobs and about 300 B€ revenues, the NESSI Technology Platform aims to provide a unified view for European research in Services Architectures and Software Infrastructures that will define technologies, strategies and deployment policies fostering new, open, industrial solutions and societal applications that enhance the safety, security and well-being of citizens.

4. STATE OF THE ART IN SERVICE ENGINEERING

As said before, the aim of the research carried out in the area of services is for companies to have the software infrastructure and tools to easily create and deploy new types of e-services. Currently the IT systems of companies are usually not flexible enough to cope with the changed caused by introducing a new e-service; one way to introduce this flexibility is by re-engineering these systems as SOA. This re-engineering is the focus of many SOA projects: Forrester Research Inc has surveyed 116 North American companies of all sizes on adoption of SOA. They found that SOA is primarily used for internal integration (37%) and much less for external integration (15%). They also found that SOA is used for multi-channel applications (9%) and strategic business transformation (9%).

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5 http://www.nessi-europe.com
6 http://www.cbdiforum.com/index.php3, Developing the Architectural Framework for SOA, Oliver Sims
7 http://searchsap.techtarget.com/originalContent/0,289142,sid21_gci1081175,00.html
Europe

In Europe, SAP, the biggest applications maker, is rewriting much of their software, to consolidate on single code-bases after recent acquisitions and to prepare for the intended architectural shift caused by SOA. This will take until 2007. For most corporate customers, SOA "could be a 2010 phenomenon".8

Software AG, another European company offers a SOA backbone for integrating information and applications across every platform in the enterprise9.

A third European player, offering an “enterprise service bus” (middleware for enabling service oriented systems) is CORDYS.10

USA

Even though many companies put the focus on using SOA to improve the flexibility of their IT systems, more and more web companies are making web services available through which third parties can add value. Examples include Amazon and Google. With the Google Web APIs service, software developers can query more than 8 billion web pages directly from their own computer programs, and develop their own applications based on the queries.11

Google is also developing a stack of software in competition with the Microsoft desktop, and one that is much more network-centric, more an Internet service.12 The idea is that these services can be used from a very thin, network enabled computer.

Amazon Web Services provide the valuable function of enabling software developers to interact with Amazon’s Web site through standard protocols. This interaction can lead to a deeper, more valuable relationship for all parties involved.

- Associates: The Associates program enables Web sites to link to Amazon.com and earn referral fees for sales that they drive through their links. Many Associates are now using the Amazon Web Services to build more effective links to Amazon’s store, thus enhancing their sites and earning more money.

- Sellers and Vendors: Amazon has thousands of third-party sellers who offer their products on Amazon’s Web site. Using the Amazon Web Services, these sellers can easily manage large quantities of inventory on Amazon’s platform and download the latest product information to make sure that their products are competitively priced.

8 Financial Times, 4 May 2005, Richard Waters: “Plugging together software may soon be painless”
9 http://www.softwareag.com/Corporate/Solutions/integration/soa/default.asp
11 http://www.google.com/apis/
12 http://www.informationweek.com/internet/showArticle.jhtml?articleID=175801667&pgno=1

http://www.heraldtribune.com/apps/pbcs.dll/article?AID=/20051211/ZNYT05/512110859/-1/AP
• Developers: Among the tens of thousands of developers who have signed up for our Web Services program, many are now creating solutions to help other people work with Amazon.  

Microsoft will also selectively offer Web services that do over the Internet some of what Office and Windows do on the desktop. It recently introduced Windows Live and Office Live. Windows Live lets consumers manage their e-mail, instant messaging, blogs, photos and podcasts in one site. Office Live enables small businesses to set up Web sites and e-mail systems, and to provide collaboration sites for teams. Both will be supported by advertising and perhaps some subscription fees. In the future also parts of Office - like Word, Excel or PowerPoint – will be offered as Web services. Microsoft needs to do this in order to compete with companies like Google.  

China

In China Software and services will account for 35 per cent of Chinese technology spending in 2009, up from 26 per cent five years earlier, estimates IDC, the technology research company. While foreigners have dominated the market so far, the jump in spending should also stimulate the growth of Chinese software companies.

China is developing their own standards and software in order to avoid to pay to foreign companies fees for licenses. They recently defined the objectives of the 11th 5 year programme (2006-2010) of the 863 research programme. Expected outcomes of the work on ‘Technology and System of Integration in Manufacturing Informationization’ (part of the 863 programme) are:

• Breakthroughs in frontier methodologies and technologies supporting key components and toolsets for the integration platforms
• R&D on integration platform for enterprise informationization. The SOA concept is recognised as being important.
• Integrated system development aiming at key industries and grand projects as well as certain regions
• Software and services based on key technologies and integration platforms
• Training of personnel, and development of R&D centres and commercialized promotion bases

A common practice in China is that once the results of the research programme are approved, they are immediately taken up by the big companies. So in the future we might expect that China will play an important role in service orientation for enterprise integration.

5. WHAT ARE THE MAIN RESEARCH CHALLENGES IN THIS AREA?

Future services will be robust, simple and easy to use with high perceived value and capable of:

13 http://www.amazon.com/gp/browse.html/103-4602978-75510687?%5Fencoding=UTF8&node=3435361

14 http://www.heraldtribune.com/apps/pbcs.dll/article?AID=/20051211/ZNYT05/512110859/-1/AP
• Being adaptive to situation and environment
• Providing “intelligent” support while leaving the user in control
• Being simply accessible through different infrastructures and devices.

There is a big gap between the current state of the art in services research and the future vision where services are all around us providing useful assistance. The following questions and issues need to be resolved in order to bridge that gap.\(^\text{15}\)

1. How should we develop services? Service developers face all the usual problems regarding how to develop software that satisfies a specification of the software requirements and how those requirements are identified in the first case\(^\text{16}\). The added dimension for service engineering is:
   • how a service is described to users and application developers that want to use the service as it is, or want to integrate that service with others to develop a new service (service description)
   • how these users can find what they require (service discovery)
   • how they can verify that what is described is what is delivered (service monitoring)
   • if they want to compose a new service on the basis of existing services, how can they do that (service composition), especially on the fly, according to the needs of a user? (dynamic composition).

2. How to provide intelligent services that leave the user in control? The challenges are to discover how much intelligence, for what purpose, in which situations, how to sense change of context, continue with tasks in a different context, adapt to other culture and language

3. How can we electronically represent all the elements that exist in a real world service? We need a rich description for expectations, requirements, contracts, existing industry processes, etc…

4. How can different types of services (web services, grid, p2p, agents) interoperate with each other and also work on different kinds of networks (internet, p2p, home networks)

At the “Future Service Engineering” workshop speakers highlighted the fact that there also needs to be more research into putting into practice service technology on a large scale, in order to investigate:

• **Quality of Service (QoS)**: Applications can be composed of several services produced by different providers and it can be difficult for one party to control the quality of others. Are the applications and their performance reliable enough to

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\(^{15}\) This is the outcome of the workshop on key challenges of service engineering (http://www.cordis.lu/ist/st/workshop_210405_se.htm)

\(^{16}\) SeCSE deliverable Service Specification State of the Art
provide the required user experience for mobile use and mass markets? Expectations are high especially if the user needs to pay for the service.

- **Trust and Privacy:** How can we ensure that privacy of the user is respected in the distributed environment? How can the user or intermediate service trust that the used service behaves respectfully and follows agreed principles? Who should be the trusted parties to control and check?

- **Added Value:** How to get the business ecosystem to provide added value for the stakeholders?

- **Billing:** In scenarios where users may access services from many different providers, how can we handle billing conveniently? Are the users able to understand the cost of the service in an easy way?

- **Electronic marketplaces:** How will electronic marketplaces as a place for discovery of enterprise services actually work?

6. **ONGOING RESEARCH IN SERVICE ENGINEERING**

Many of the research aspects of Section 5 will be addressed under the NESSI Strategic Research Agenda, which is currently under development. A first version may be downloaded from www.nessi-europe.com. NESSI approaches services holistically and will include research into business models, service lifecycles and systemic aspects as well as technology (Figure 5.1). The final Strategic Research Agenda is likely to focus on aspects such as: business dynamics, service science and engineering; service engineering system science; and open source science.

![Figure 5.1: NESSI Services Research](image)

Through the IST program the European Commission is currently funding research in Service Engineering. This section has been based on results of the running projects in this area\(^{17}\). It briefly describes how each of the projects is contributing to the 4 technical challenges described above.

The following table provide a schematic overview of the main topics of the projects:

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\(^{17}\) [www.cordis.lu/ist/st/projects.htm](http://www.cordis.lu/ist/st/projects.htm)
Service development SeCSE, ASG, Sodium, Infrawebs
Human/service interaction, adaptation Amigo, ASG, MADAM
Representation of real world ASG, Infrawebs
Interoperability and standardisation Sodium, WS2, ASG, SeCSE

6.1. Current IST Research and Challenge 1: How should we develop services?

SeCSE\(^{18}\) is one of the projects working on the topic of Service Development. A project result of interest to the service engineering community at large is the “SeCSE conceptual model” which explains concepts that are important within the SeCSE project. The model clarifies:

- The meaning of a “service”
- The difference between a service and its public description
- The distinction between “simple” vs “composite” and “stateless” vs “stateful” services
- The various actors that exploit, offer, and manage services
- The relevant aspects concerning service discovery, composition, publication, execution and monitoring \(^{19}\)

SeCSE has also developed a methodology for service engineering, tackling the need for significant service discovery activities both during the requirements engineering phase of a project and also at run-time, when service discovery is needed in order to decide whether to start re-negotiation and re-planning in order to optimise the overall quality of a service composition.\(^{20}\)

The ASG\(^{21}\) project aims to build a platform which will perform and support a service delivery lifecycle, enabling provision and consumption of complex services. A key concept is that ASG will use semantic information about services to fulfil user requests. Service in ASG are thus described not only syntactically (the technical interface to invoke a service) but also semantically. These semantics are represented by semantic service specifications, which include functional and non-functional properties and rely on ontologies from various industrial domains. ASG components can make use of this information about what a service does in addition to how it does it.

\(^{18}\) [http://secse.eng.it](http://secse.eng.it)


\(^{21}\) [http://asg-platform.org/](http://asg-platform.org/)
The project Infrawebs\textsuperscript{22} is taking another approach. They investigate how to semi-automatically convert (normal) web services into semantic web services using semantic web technologies.

The diversity among the existing service oriented technologies renders the integration of different types of services a challenging task. In order to address this issue, the SODIUM\textsuperscript{23} project provides a Generic Service Model (GeSMO) which specifies a set of core concepts for services as well as various extensions for specific service types.

GeSMO has been developed after a thorough investigation of the features, properties and characteristics of all service types, focusing in particular on web, grid and p2p services. However, it is generic (as it provides the basis for modeling all service types, e.g. Jini services, sensor services, etc., although in SODIUM the provided extensions address web, grid and p2p services only), abstract (it specifies abstract concepts describing all service types), modular (related information and properties are grouped in independent modules, thus allowing the easier modification and extension of specific information parts), extensible (it can be easily extended with features and properties currently not addressed by the existing service technologies), expressive (it accommodates features and properties that support all service activities such as, discovery and composition) and simple (in order to support all types of users and tools that will are based upon it).

6.2. Current IST Research and Challenge 2: How to provide supportive intelligent services to users but leave them in control?

The fundamental idea behind the MADAM\textsuperscript{24} project is that context awareness and adaptation can be supported by generic middleware solutions in the form of extensions to methods, languages, middleware, and tools. Together these results will facilitate the engineering of adaptive applications.

\textsuperscript{22} http://www.infrawebs.org

\textsuperscript{23} http://www.atc.gr/sodium/index.asp

\textsuperscript{24} http://www.ist-madam.org/
In MADAM the user requests the type of service needed, specifying logical functionality and requirements for non-functional properties (such as QoS). Then the adaptation middleware discovers and selects the service type implementation that best meets the end-user’s requirements given the current context. The middleware also detects context changes, discovers alternative application or service implementations and reconfigures application and service implementations accordingly to maintain user satisfaction.

The AMIGO project develops middleware to achieve interoperability of devices, artefacts, and services; aiming at intelligent user services within three application domains: homecare and safety; home information and entertainment; and extended home environments. The project has applied a scenario-driven approach to establish the user requirements based on feedback from potential users on the usefulness and appropriateness of applications and services. The main finding has been that there is a fine balance to be made by the application developer between the system being “smart” and the need to protect privacy. Data from sensors can be collected and used to support people and to improve system functionality; but people also have the right to control which data are collected and by whom and how they are used.

The key findings of a session organised by these two projects at the “Future Service Engineering” workshop were:

- There is an inherent conflict between leaving the user in control and achieving self-configuration and adaptation of complex systems.
- Complexity is an unavoidable consequence of system size.
- Key user concerns are privacy and security of the automatically collected and stored data.
- Research is needed to understand the best ways for a user to control complex applications while maximising the degree of autonomic application behaviour.
- Research is also needed to develop new ways for users to interact and control such complex distributed systems.

6.3. Current IST Research and Challenge 3: How can we electronically represent all the things that exist in a real world service?

This question is partially addressed by the project Infrawebs which develops a Fuzzy Set based organisational memory. Its management module is endowed with tools for knowledge acquisition, knowledge representation, and information retrieval. Each imprecise concept is defined as a set of fuzzy concepts (using methods of implicit semantics), which is related to a set of imprecise terms representing the context.

Involving and considering also formal semantics, these imprecise terms (words) are “translated” into precise terms (words) formalised as an ontology (within an ontology).

Domain ontologies are a core concept within ASG. Since ASG aims at providing real-world business scenarios it is crucial to define a domain-specific ontology to specify relevant concepts and their interrelationships for the respective industry (or at least company).

Every service that plays a role in an industrial usage scenario needs to be semantically described using the concepts of the domain ontology. This implies that external services interfaces need to be mapped (mediated) to the concepts of the ontology.

The benefit in using a common ontology is that it becomes possible to formally describe behavioural and non-functional aspects of a service implementation enabling powerful discovery and service composition mechanisms. The challenge in defining an ontology is to find the correct level of granularity. Coarse-grained ontologies are relatively easy to develop, but they result in fuzzy service descriptions making service discovery and composition difficult with high risk of low precision in results. On the other hand the modelling of fine grained ontologies is laborious, but it allows for accurate descriptions of service semantics which eases service discovery and composition and leads to more precise results.

6.4. Current IST Research and Challenge 4: How can different types of services interoperate with each other and also work on different kinds of networks

This topic was discussed by the projects ASG, SODIUM and WS2 at the “Future Service Engineering” workshop. Interoperability is a multi-dimensional issue. Some dimensions are: platform related interoperability, application related interoperability and domain related interoperability.

As mentioned before, the project SODIUM is defining a generic service model for web, grid and p2p services.

Other projects (SeCSE, ASG, INFRAWEBS, WS2) want to contribute to semantic web services standards. An important European initiative in this area is WSMO\(^\text{26}\) (Web Service Modelling Ontology).

In June 2005 W3C organised a workshop for semantics in web services in Austria. During that workshop it was noted that there seems to be little industrial interest in semantic web services. Some reasons for this are the following:

- approaches like WSMO and OWL-S are complicated (one reason for this is that they try to cover everything from grounding to internal choreography), overlapping, incompatible in some respects, etc.
- there exist many different ontologies for a specific domain. Thus, even if one uses one of the above standards, semantic interoperability is still not guaranteed.
- there are still no mature tools to support WSMO or OWL-S.
- the need for using semantics has not yet been fully acknowledged by industry.
- industry expects more concrete and simpler standards, supported by robust tools.

What should be done next?

- provide simpler approaches for discovery and description, like WSDL-S.

\(^{26}\) [http://www.wsmo.org/](http://www.wsmo.org/)
- demonstrate the benefits of using semantics by developing pilots and best practices focused on every-day needs of consumers, citizens, organizations, industry etc.
- develop upper standard ontologies per domain (to serve as a common denominator for supporting interoperability).

7. **FURTHER WORK**

At the time of publishing this document various new projects in the area of service engineering will start, and new challenges will arise. This document will therefore be revised in order to include some of the results of these projects and how they relate to the research challenges. If you have any feedback about this document or suggestions for the next version, please provide your ideas to Anne-Marie Sassen (anne-marie.sassen@ec.europa.eu).