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PROJECT PERIODIC REPORT

Grant Agreement number: 288879

Project acronym: CALIPSO

Project title:

CALIPSO: Connect All IP-based Smart Objects!

Funding Scheme: STREP

Date of latest version of Annex I against which the assessment will be made:

June 14th, 2011

Periodic report: 1st ☐ 2nd ☒ 3rd ☐ 4th ☐

Period covered: from 01/09/2012 to 31/08/2013

Project co-ordinator name, title and organisation:

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Project website address: www.ict-calipso.eu

1 Declaration by the project coordinator

I, as co-ordinator of this project and in line with my obligations as stated in Article II.2.3 of the Grant Agreement declare that:

- The attached periodic report represents an accurate description of the work carried out in this project for this reporting period;
- The project (tick as appropriate):

  ☒ has fully achieved its objectives and technical goals for the period;

  ☐ has achieved most of its objectives and technical goals for the period with relatively minor deviations[1];

  ☐ has failed to achieve critical objectives and/or is not at all on schedule.

- The public Website is up to date, if applicable.
- To my best knowledge, the financial statements which are being submitted as part of this report are in line with the actual work carried out and are consistent with the report on the resources used for the project (section 3.6) and if applicable with the certificate on financial statement.
- All beneficiaries, in particular non-profit public bodies, secondary and higher education establishments, research organisations and SMEs, have declared to have verified their legal status. Any changes have been reported under section 5 (Project Management) in accordance with Article II.3.f of the Grant Agreement.

Name of Coordinator: Jérôme LEGUAY

Date: 15 / 10 / 2013

Signature of Coordinator: [signature]

1 If either of these boxes is ticked, the report should reflect these and any remedial actions taken.

2 Publishable summary

Logo:

Project acronym: CALIPSO

Project title: CALIPSO: Connect All IP-based Smart Objects!

Web: www.ict-calipso.eu

Contractors:

Role	No	Partner name	Partner short name	Country
CO	1	Thales Communications & Security	TCF	France
CR	2	CNRS	CNRS	France
CR	3	Swedish Institute of Computer Science	SICS	Sweden
CR	4	University of Parma	UPA	Italy
CR	5	Disney Research Zurich	DRZ	Switzerland
CR	6	Worldsensing	WOS	Spain
CR	7	CISCO	CISCO	Belgium

Project co-ordinator Contact Details:

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Smart Objects and the Internet of Things provide unparalleled means to connect the physical world with the digital world, enabling important applications such as Smart Infrastructures, Smart Cities, and Smart Toys. But existing systems are typically proprietary and tailored to one specific application and sacrifice interoperability for low power consumption.

Main objectives

The EU-FP7 CALIPSO project is devoted to the development of Internet Protocol (IP) connected smart object networks, but with novel methods to attain very low power consumption, thereby providing both interoperability and long lifetimes.

- CALIPSO leans on the significant body of work on sensor networks to integrate radio duty cycling and data-centric mechanisms into the IPv6 stack, something that existing work has not previously done. CALIPSO works at three layers: the network, the routing, and the application layer. We also revisit architectural decisions on naming, identification, and the use of middle-boxes.
- CALIPSO works within the IETF/IPv6 framework, which includes the recent IETF RPL and CoAP protocols. This gives a structure for evaluation that has not previously been available. We use Contiki open source OS, Europe's leading smart object OS, as the target development environment for prototyping and experimental evaluation.
- We use three applications to drive our work: Smart Infrastructures, Smart Cities, and Smart Toys, all of which need both standardized interfaces and extremely low power operation. We see experimental validation and evaluation as critical to the success of the project.

CALIPSO's Project Vision

Despite significant recent advances in standardization for IP-based smart object networks, there are still questions left in terms of achieving extremely low power consumption at the radio and MAC layers and its impact on the higher layers, as well as in reliability and data-centric approaches at the transport and application layers. CALIPSO identifies and addresses those issues.

Architectural Vision. CALIPSO sees that smart object networks both need to communicate with other smart object, other smart object networks, as well as Internet-based systems. We push IP end-to-end connectivity all the way into the smart objects through compact, energy efficient, and loss/failure tolerant routing and radio protocols.

The need for all-IP smart objects lies in their heterogeneity where many vendors propose their technologies that are usually incompatible with each other and tailored to a specific application. Interconnecting them with the Internet protocols requires multiple adaptation devices, which is inefficient and costly. In contrast to this approach, we promote the use of a single interconnection protocol and aim at investigating all open research issues raised by pushing IP to smart objects.

Technical Vision. CALIPSO focuses on three specific layers of the IP stack: the routing layer, the transport layer, and the application layer. CALIPSO takes a unified approach, where we acknowledge the dynamics between the layers, which as of today are not yet understood. With deepened understanding of the complex interactions between the layers, CALIPSO will be able to significantly increase the performance and reduce the power consumption of IP-based smart object networks, thereby removing major barriers to IP adaptation. We define a transport layer adaptation and a suitable sublayer for SANET mapping, enhance the IETF CoAP RESTful protocol, and provide a large scale service to discover possible data sources and consumers.
Expected impact and applications

We expect CALIPSO results to impact four areas: standards, open source software, scientific research, and commercial products. Project partners have extensive experience in the application domains, the IETF, sensor networks, and open source software.

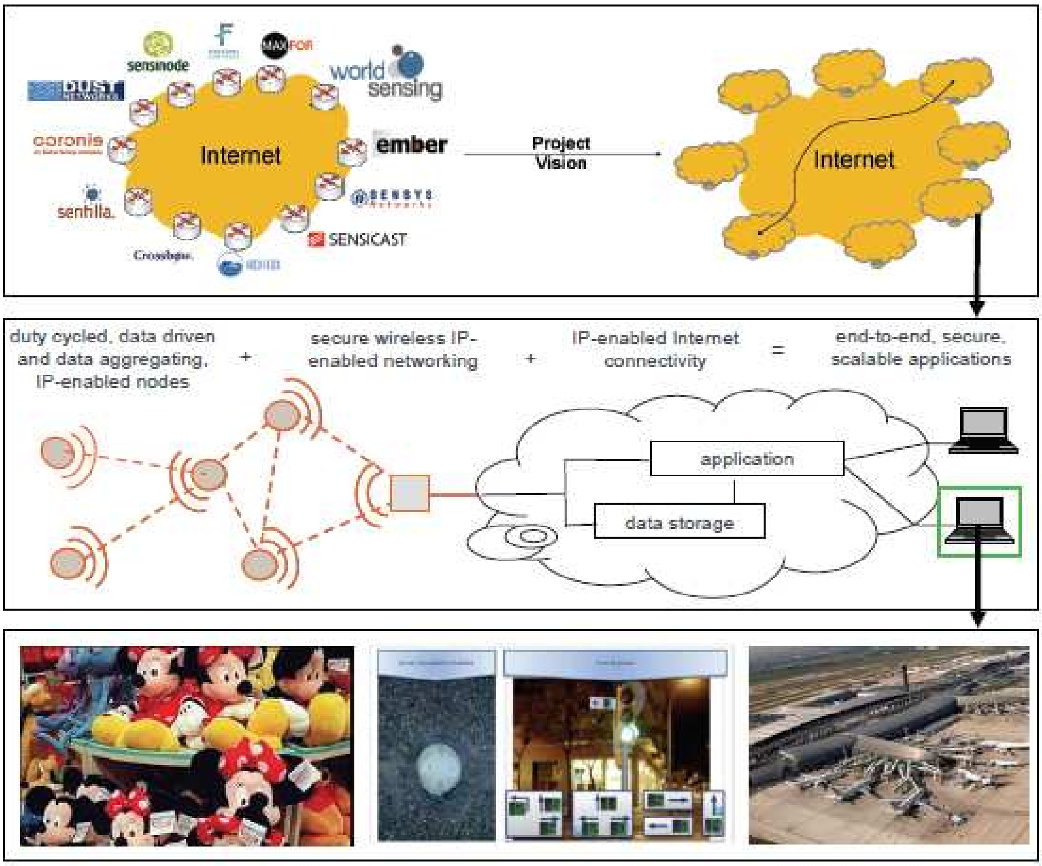

Figure 1: CALIPSO's vision

We focus on three types of smart objects and applications: (1) Smart Toys, (2) Smart City, and (3) Critical Infrastructures. All three have in common that they usually support a single application and use proprietary protocols and wireless technologies optimized for reduced energy consumption. Significant recent efforts aim at making them more generic and interconnecting with end-hosts on the Internet in an energy efficient way.

Overall strategy of the work plan

CALIPSO achieves its objectives by conducting high quality research structured in six work packages:

WP1 Efficient project management and interaction with the Commission.

WP2 Wide dissemination of project results, pushing innovative solutions to standardisation bodies (mainly IETF and IEEE), exploiting the technology developed in the project by industrial partners, and stimulating the reuse of project results in industry.

WP3 Designing an architecture for the Internet of Smart Objects. This work package considers all architectural issues related to IP protocols in large-scale networks of smart objects, and provide a framework of use cases and requirements to other work packages.

WP4 Developing required mechanisms and solutions for large-scale IP interconnection of smart objects operating over duty-cycling access methods. In this work package, we enhance MAC–IP integration, optimize the operation of RPL, and design new data-oriented mechanisms.

WP5 Designing a support for applications and end-to-end communications. This work package provides solutions for supporting a high-level view of smart objects: optimized CoAP with security extensions, large-scale service discovery, and data centric application support.

WP6 Experimentally validating the integrated IP stack with target applications. We commit to testbed deployment and experimental validation with two applications: Smart Toys in theme parks and Smart City/Parking.

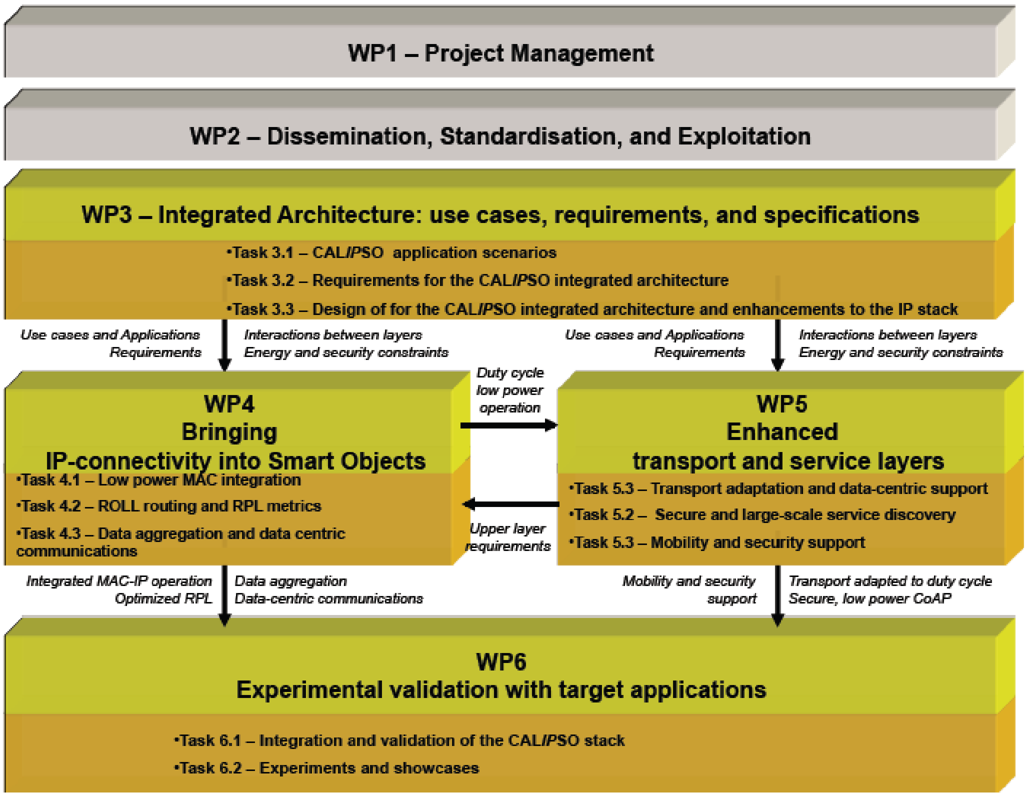

Figure 2 Work package structure.

Project objectives & achievements for the period

While project management and dissemination activities are maintained during the whole project duration, work packages 3–6 go through three phases:

Phase 1 (9 months): During the first phase of the project, we will focus on the architectural issues, uses cases, and requirements of target application scenarios. This work is mainly related to the activities of WP3 (Architecture).

Phase 2 (15 months): The second phase aims at developing required mechanisms and solutions at all layers. This work is mainly related to the activities of WP4 (IP connectivity) and WP5 (Transport and Application support).

Phase 3 (12 months): The third phase will focus on testing and evaluating the proposed mechanisms of the integrated stack in two target application scenarios. This work is mainly related to the activities of WP6 (Experimental Validation).

In this first period, we thus finalized Phase 1 and 2.

CALIPSO's use cases

The project targets three main applications: i) Smart Toys, ii) Smart City/Parking, and iii) Critical Infrastructures.

- Smart Toys are radio-enabled devices whose primary function is entertainment/gaming, but they may also provide additional functionalities, such as sensing/monitoring, education, and multimedia communication. They may appear in various forms depending on the target user group (kids, teenagers, adults) and may be equipped with a variety of sensors (microphone, camera, accelerometer), user interfaces (display/touch screen, buttons/keyboard, or none), and radios (IEEE 802.11 and its low power versions, Bluetooth, IEEE 802.15.4/Zigbee). Toys can be used in theme parks, homes, schools, hospitals.
- Smart parking uses sensor nodes to communicate parking space availability/traffic flow to neighbouring sensors until they reach the gateway. Multi-hop routing is used when direct contact with the gateway cannot be made. A centralized control system stores and processes all data gathered from sensors. The resulting information and implemented services are offered to citizens by means of mobile applications and city panels.
- Critical infrastructure makes use of low-cost, easily deployable sensors can increase situation awareness and help anticipating better threats within or around an area. The requirements are to detect as soon and as reliably as possible an abnormal event, raise an early warning to the operator, which in turn issues an action in response. Public safety operators can deploy low power additional observation means that are discovered and usable by a mobile or fixed (Control & Command) C2 right away.

CALIPSO's architecture

CALIPSO sees that smart object networks both need to communicate with other smart object, other smart object networks, as well as Internet-based systems. We thus push IP end-to-end connectivity all the way into the smart objects through compact, energy efficient, and loss/failure tolerant routing and radio protocols. CALIPSO takes one step further in bringing IP to low-power, duty cycled devices.

The need for all-IP smart objects lies in their heterogeneity where many vendors propose their technologies that are usually incompatible with each other and tailored to a specific application. Interconnecting them with the Internet protocols requires multiple adaptation devices, which is inefficient and costly. In contrast to this approach, we promote the use of a single interconnection protocol and aim at investigating all open research issues raised by pushing IP to smart objects. This leads to a cost-effective, scalable, secure, and IP-enabled architecture that connects physical and digital smart object worlds.

Analysing the CALIPSO use cases, we have identified the enhancements required to the standard IP stack to operate in networks of Smart Objects and specify the interactions between layers. Figure 3 presents a layered view of the architecture for a Smart Object node and a border gateway. The gateway (or LBR, the border router in the IETF terminology) supports the standard TCP/IP protocol stack and adapts its operation to Smart Object nodes. The main function of the gateway relates to the 6LoWPAN layer that takes care of fragmenting packets longer that the L2 MTU and compresses headers. It can also provide interfacing CoAP with standard HTTP. We can observe that lower layers include several different PHY/MAC layers that the project may use in different testbeds.

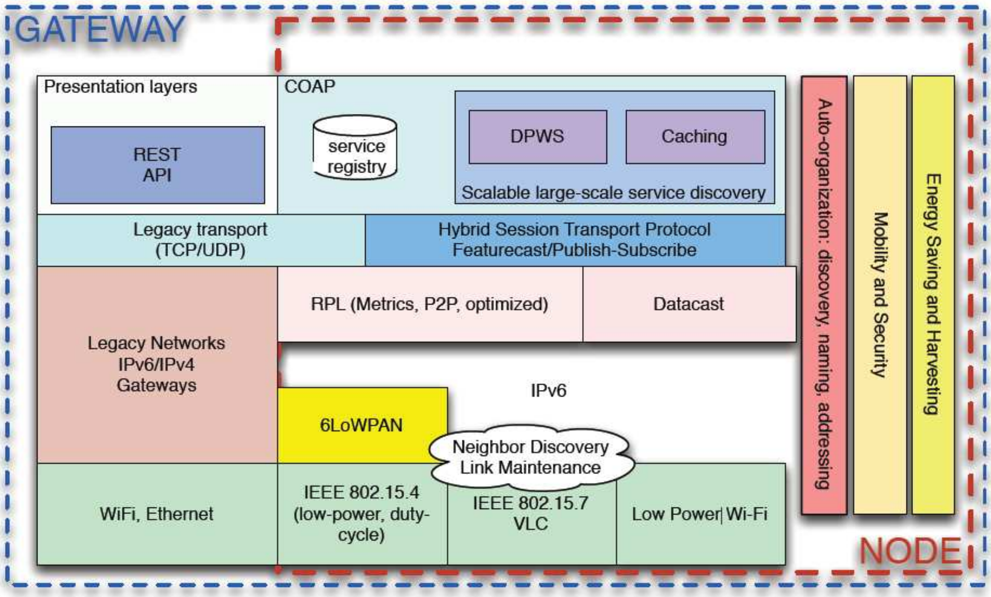

Figure 3: CALIPSO Architecture.

Figure 4 illustrates a functional view of the architecture. Bold shapes indicate the blocks on which the project will focus by providing enhancements, optimizations, or adaptations to Smart Objects constraints. The figure shows that almost all aspects concern our project and only two protocols are used as is in the project: 6LoWPAN header compression and fragmentation, and legacy transport.

For each of the building blocks of the architecture, we have proposed a number of technical solutions available in more details in the following documents:

- D4.41 “Protocols for Low Power MAC–IP”
- D4.42 “Enhancements to ROLL Routing and RPL”
- D4.43 “Protocols for data aggregation and data centric communications”
- D5.51 “Transport adaptation and data-centric support“
- D5.52 “Secure and large-scale service discovery”
- D5.53 “Mobility and security support”

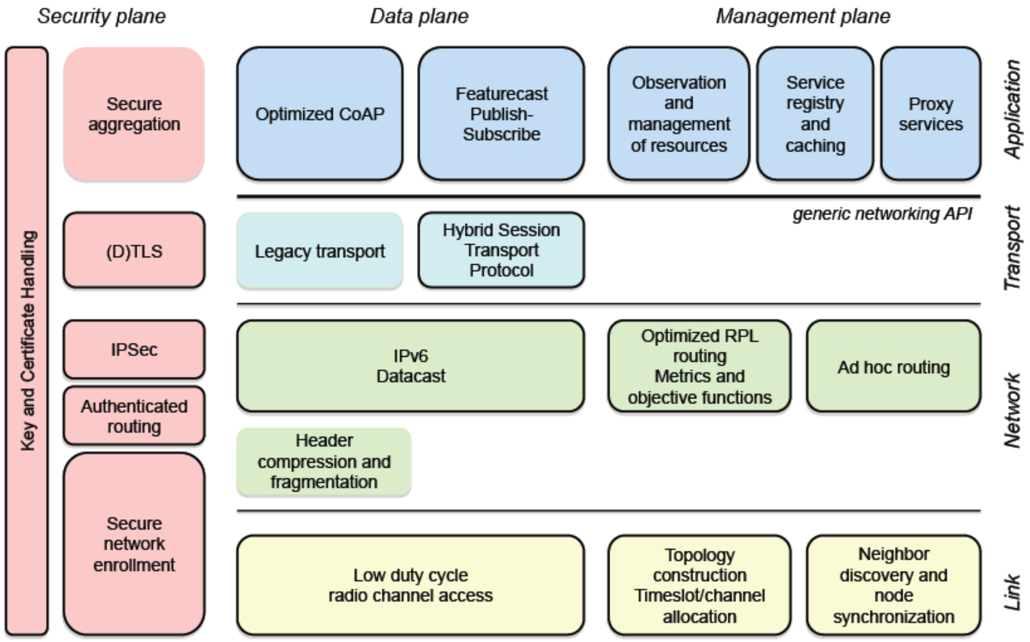

Figure 4: Functional view

After the experimentation phase that project is going to start in WP6, we will refine the proposed architecture in deliverable D3.33.

For further information:

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At a Glance

Project

CALIPSO: Connect All IP-based Smart Objects!

Project coordinator

Thales Communications & Security (France)

Partners:

CNRS (France)

Swedish Institute of Computer Science (Sweden)

University of Parma (Italy)

Disney Research Zurich (Switzerland)

Worldsensing (Spain)

CISCO (Netherlands)

Duration

36 months (09/2010 – 08/2014)

Total cost: 4,56 M€

3 Work progress and achievements during the period

This section reviews the progress and achievements of all the work packages listed in Table 1.

Work-package	Workpackage title	Lead contractor	Person-months[2]	Start month	End month	Deliv-erable No[3]
WP1	Project Management	TCS	15	M1	M36	D1.122
WP2	Dissemination, Standardisation, and Exploitation	WOS	45	M1	M36	D2.231 D2.241
WP3	Integrated Architecture: use cases, requirements, and specifications	CNRS	53	M1	M30	D3.32a D3.32b
WP4	Bringing IP-connectivity into Smart Object	SICS	68	M9	M24	D4.41 D4.42 D4.43
WP5	Enhanced transport and service layers	UPA	46	M9	M24	D5.51 D5.52 D5.53
WP6	Experimental validation with target applications	DRZ	51	M24	M36	
	TOTAL		278			

Table 1: Work package list, schedule, efforts and deliverable (for the reporting period only)

2 The total number of person-months allocated to each workpackage.
3 Deliverable number: Number for the deliverable(s)/result(s) mentioned in the workpackage: D1 - Dn.

3.1 WP1 - Project Management

WP1				**Start date**	Month 1			
Leader:	TCS			**End Date:**	Month 36			
Participants		**TCS**	CNRS	SICS	UPA	DRZ	WOS	Cisco
Resources (PMs)	**Planned**	9	6	0	0	0	0	0
	Actual	5.30	3.95	0.0	0.0	0.0	0.0	0.0

3.1.1 Objectives and organization of the Work Package

The main objectives of this work package are to set up the management infrastructure, to provide technical and administrative assistance to the coordinator and partners, to provide financial and contractual management of the consortium, to ensure execution of the project in conformity with the Commission contract and the Consortium Agreement, to negotiate any necessary changes to these agreements during the project, and to manage risk and to perform contingency planning. Namely:

- to perform the administrative, scientific/technical, and financial management of the project
- to co-ordinate the contacts with the European Commission
- to control quality and timing of project results and to resolve conflicts
- to set up inter-project communication rules and mechanisms
- to achieve timely submission of progress reports and cost statements to the European Commission
- to ensure that the Description of Work and the Consortium Agreement are maintained and updated where and when necessary

This work package is composed of the following tasks:

- Task 1.1 [Lead TCF] – Project Administration.
- Task 1.2 [Lead TCF] – Project Quality Assurance.

3.1.2 Tasks addressed during the period

During the reporting period, the following actions were carried out within the different tasks of the work package to satisfy the success criteria:

- Planning and global work plan.
- Analysis of reviewers comments for D3.321 and overall technical planning
- CALIPSO plenary meetings preparation (Parma, Grenoble, Barcelona).
- Organization and handling conference calls
- Coordination of quarterly reporting activities
- Preparation of 2nd year project review (October 29th and 30th)
- Preparation of D1.121 “Periodic activity report” (M24)

- Communication of the 2nd period deliverables to the Advisory Board and coordination for the preparation to answers from the consortium.

3.1.3 Major achievements and next steps

The major achievements of the work package are:

- 1st project review meeting in Brussels, Belgium
- Preparation of D1.121 “1st Periodic Management Report” (M24)
- Quality assessments of reporting and deliverable documents.
- Planning and global workplan.

The next steps planned for the WP are:

- Manage the feedback from the 2nd project review and coming comments from Advisory board members
- Organize the next project meeting and conference calls
- Quality assessments of reporting and deliverable documents.
- Coordination of quarterly reporting activities

3.1.4 List of project meetings, dates and venues

- Project review meeting - October 10th, 2012
    - Brussels, Belgium
- Fifth plenary meeting - November 5th & 6th, 2012
    - UPA, Parma, Italy
- Sixth plenary meeting – February 21th & 22th, 2013
    - CNRS, Grenoble, France
- Seventh plenary meeting - June 6th & 7th, 2013
    - WOS, Barcelona, Spain

3.1.5 CALIPSO Advisory Board

The Advisory Board is composed of the following member (help here):

Name	Organization	Role
Thomas Wattenye	Dust Networks, USA	Involved in the ROLL IETF working group. Authors of IETF RFC 5548.
Laurent Toutain	Telecom Bretagne, France	Research assistant. Contributor in the French ARESA2 project.

Dr. Andreas Terzis	Johns Hopkins University, USA	Andreas Terzis is an Associate Professor in the Department of Computer Science at the Johns Hopkins University, where he heads the Hopkins InterNetworking Research (HiNRG) Group. His research interests are in the area of computer networks with an emphasis on low-power and sensor networks. Dr. Terzis is a recipient of the NSF CAREER award (NSF being the main funding agency for non-medical research and education). Dr Terzis is also active at the IETF and co-authored 3 RFC, rfc2745, rfc2746 and rfc3836, on the Resource Reservation Protocol (RSVP) and Open Pluggable Web Services (OPES).
Prof. Dr. Pedro José Marrón	University of Duisburg-Essen, Germany	Pedro José Marrón is a Professor at the University of Duisbourg Essen, where he leads the Networked Embedded Systems (NES) group. Prof. Marrón has an extensive experience with EU projects. He was the coordinator of the CONET FP7 Network of Excellence (NoE). He also is or has been coordinating and/or participating to a number of other EU-projects including Embedded WiSeNts, EMMA, AWARE, PECES, and PLANET.

3.1.6 Advisory board feedback and answers

The deliverables has been sent to advisory board members. The consortium is waiting for their feedback.

3.1.7 Project planning and overall status

The following tables summarize the current resources per work package and per partner with regards to planned resources for the whole duration of the project.

			TCS	CNRS	SICS	UPA	DRZ	WOS	CISCO	Total	Progress (%)
WP1 - Project Management	M1-M36	actual	5,30	3,95	0,00	0,00	0,00	0,00	0,00	9,25	61,67
		planned	9,00	6,00	0,00	0,00	0,00	0,00	0,00	15,00	
WP2 - Dissemination, Standardisation	M1-M36	actual	4,60	1,08	1,92	4,15	3,50	7,10	4,50	26,85	59,67
		planned	7,00	4,00	4,00	5,00	7,00	8,00	10,00	45,00	
WP3 - CALIPSO Architecture	M1-M30	actual	9,35	9,14	6,52	4,55	8,00	13,80	1,90	53,26	100,50
		planned	8,00	9,00	7,00	4,00	8,00	13,00	4,00	53,00	
WP4 - Bringing IP-connectivity into Smart Objects	M9-M24	actual	6,45	19,09	11,00	13,09	8,50	14,40	1,40	73,93	108,72
		planned	6,00	19,00	11,00	12,00	4,00	12,00	4,00	68,00	
WP5 - Secure applications for mobile Smart Objects	M9-M24	actual	15,00	3,05	10,00	11,01	1,00	0,00	0,00	40,06	87,09
		planned	17,00	3,00	10,00	10,00	6,00	0,00	0,00	46,00	
WP6 - Experimental validation	M24-M36	actual	0,50	0,00	0,00	0,00	1,00	0,56	0,00	2,06	4,04
		planned	5,00	6,00	3,00	3,00	14,00	20,00	0,00	51,00	
Total		actual	41,20	36,31	29,44	32,81	22,00	35,86	7,80	205,42	73,89
		planned	52,00	47,00	35,00	34,00	39,00	53,00	18,00	278,00	
Progress (%)			79,23	77,26	84,11	96,50	56,41	67,66	43,33	73,89	

Figure 5: Effort consumption during the reporting period

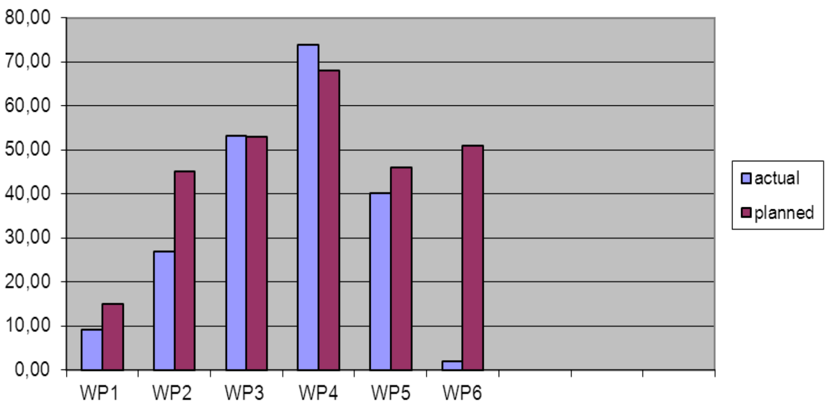

Figure 6: Per WP effort consumption during the first period v.s. total resources allocated for the whole project duration

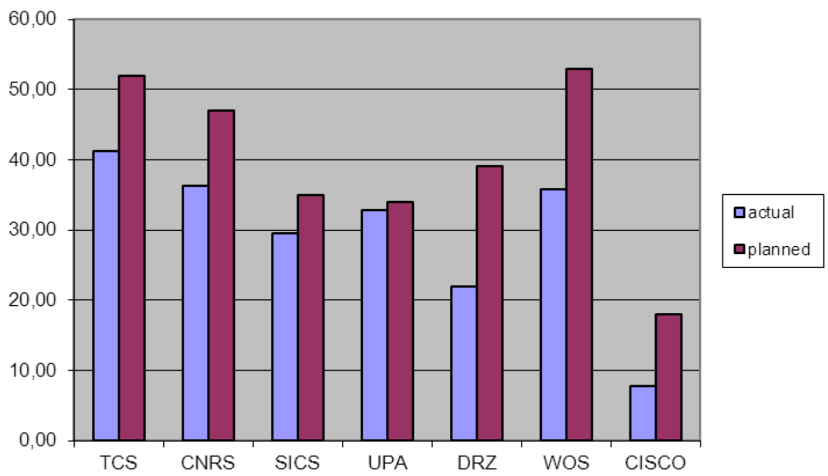

Figure 7: Per Parner effort consumption during the first period v.s. total resources allocated for the whole project duration

3.1.8 Deviation and corrective actions

TCS

TCS has consumed 41.20PM over 52PM in the project. The efforts are inline with the original plan. A slight shift of efforts (about 1PM) has occurred from WP5 to WP4 to work on RAWMAC which was necessary for the Smart Infrastructure use case that Thales is leading.

CNRS

CNRS has consumed 36.31 PM over the total of 47 PM in the project, which represent 77.25%. The increased consumption with the respect to the uniform distribution of PMs over the project duration comes from the particular effort during the second year of the project devoted to the work WP4 and WP5: the technical work packages terminate at the end of the second year and CNRS has an important allocation of resources in these packages (WP4 - 19PMs, WP5 - 3PMs).

SICS

SICS has consumed 29.44 PM (19.93 in year 2) out of the 35 PM available in total. This is explained by WP4 and WP5, where the bulk of SICS' resources is, having ended at M24. In the third year, SICS will focus on dissemination and standardization (WP2, more than 50% of the SICS manpower left for third year) and on experimental validation (WP6, starting year 3).

UPA

UPA has consumed (over the first two years of CALIPSO) 32.81 PM over the total of 34 PM in the project, which represent 96.5%. The increased consumption with the respect to the initially foreseen number of PMs over the project duration comes from the particular effort (already started at the end of the first year and due to the academic nature of UPA) dedicated to WP4 and WP5. In particular, UPA dedicated one more PM for each of these two work packages (13.1 PM, instead of 12.0 PM, for WP4; 11.01 PM, instead of 10.00, for WP5), together with supplementary 0.56 PM dedicated to WP3 (4.56 PM instead than 4.00 PM). This has been due to a relevant internal research activity.

DRZ

DRZ has consumed (over the first two years of CALIPSO) 8.5 PM in WP4, which is an increase over the panned 4 PM. However, in WP5, only 1 PM was consumed out of planned 6 PM. The reason is because mobility support work has been moved from WP5 to WP4. The cumulative PM consumption for WP4 and WP5 (9.5 PM) is still in line with the planned consumption (10 PM).

WOS

WOS has consumed 35,9 over the total of 63,45 PM in the project, which represent 56,5%. The deviation over the uniform distribution of PMs over the project duration is produced because during the first and the second year of the project the tasks carried have been mainly research activities more focused for academia, while the third year of the project focuses more on industrial tasks. This last third year WOS will provide a huge effort carrying the tasks of WP6.

Cisco

The reasons for claiming less MMs than in the first year are related to less time spent by a senior Consultant Engineer which implies a higher cost including his salary and overhead. We budgeted less cost / MMs during the preparation of the proposal which was based on different contributors which were impacted by an internal restructuring. However Cisco assures their responsibility and will maintain and fulfil their commitments during the whole project.

3.1.9 Comments on the overall progress

The overall technical progress was important during the second year. Much work has been done within WP4 and WP5. The work in these work packages terminates by the end of the second year, so the project has done the design and technical development of the main mechanisms. The results of WP4 and WP5 are reported in several deliverables (D4.41, D4.42, and D4.43, D5.51, D5.52, and D5.53). We have integrated the results within the design of the CALIPSO Architecture reported D3.322. The work has proceeded as planned.

3.2 WP2 - Dissemination, Standardisation, and Exploitation

WP2				**Start date**	Month 1		
Leader:	WOS			**End Date:**	Month 36		
Participants		TCS	CNRS	SICS	UPA	DRZ	**WOS**	Cisco
Resources (PMs)	**Planned**	7	4	4	5	7	8	10
	Actual	4,60	1,08	1,92	4,15	3,50	7,10	4,50

3.2.1 Objectives and organization of the Work Package

This work package is set up to ensure the best wide-scale integration, communication, and synergetic presentation of the project results. It will promote the results, disseminate them to the scientific community via journals and conferences, and contribute to standardisation bodies.

The detailed objectives are the following:

- Market assessment and analysis concerning IP enabled Smart Objects.
- Promote and disseminate the results of the project as they become available in reputable journals, magazines, conferences.
- Disseminate evolving project results by actively participating in exhibitions and/or organise events, such as conferences, workshops, special issues in magazines/journals.
- Create a framework for the successful exploitation of project results and specify the exploitation plans of the project as a whole and for each partner individually.
- Contribute to standardisation bodies such as IETF, ETSI, and IEEE.

This work package is composed of the following tasks:

- Task 2.1 [Lead CNRS] – Project Web site.
- Task 2.2 [Lead TCF] – Market Assessment and Exploitation Plans.
- Task 2.3 [Lead UPA] – Dissemination and Workshops.
- Task 2.4 [Lead CISCO] – Contribution to Standardisation.

3.2.2 Tasks addressed during the period

During the reporting period, the following actions were carried out:

- Periodic update of the CALIPSO web site with events, publications and use cases
- Preparation and delivery of D2.231 “Market Analysis and Exploitation Plan” (M18)
- Preparation and delivery of D2.241 “Dissemination and Standardisation Report” (M24)
- Main publications produced through CALIPSO’s research activities in reverse chronological order, distinguishing between journal publications and conference
    - Journals
        1. L. Wallgren, Shahid Raza, and Thiemo Voigt, Routing attacks and countermeasures in the RPL-based Internet of Things, International Journal

of Distributed Sensor Networks, vol. 2013, Article ID 794326, 11 pages, 2013. DOI:10.1155/2013/794326.

2. Prasant Misra, Luca Mottola, Shahid Raza, Simon Duquennoy, Nicolas Tsiftes, Joel Hoglund, and Thiemo Voigt. Supporting Cyber-Physical Systems with Wireless Sensor Networks: An Outlook of Software and Services. Journal of the Indian Institute of Science: Cyber Physical Systems Issue, September 2013.
3. S. Raza, H. Shafagh, K. Hewage, R. Hummen, and T. Voigt, Lithe: Lightweight secure CoAP for the Internet of Things, IEEE Sensors Journal, available online in August 2013. DOI: 10.1109/JSEN.2013.2277656.
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- Book Chapters

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- Main talks/presentations related to CALIPSO’s activities

  - IoT Week 2013, June 2013, Helsinki, Finland. Paolo Medagliani (TCS), presented the activities of CALIPSO (through a talk entitled “Challenges in Future Smart Cities Services”) in the Panel Session “IoT for Smart City.”
  - IERC AC1 meeting (IOT architectures), November 2012, at SAP Research premises, Regensdorf (Zurich), Switzerland. The activities of CALIPSO were presented by Andrzej Duda (CNRS) and Vladimir Vukadinovic (DRZ).
  - Presentation by Mischa Dohler, within the IEEE ComSoc Distinguished Lectureship Tour China, on “Machine-to-Machine - Standards, Technologies, Applications,” @ Shenzhen ComSoc Chapter, July 2012.
  - IoT Week 2012, June 2012, Venice, Italy. Gianluigi Ferrari (UPA) presented the project CALIPSO at the IERC panel on IPv6 (within the session IoT and IPv6, http://www.iotweek. eu/iot-week-2012/programme-1/wednesday-1/ipv6-and-iot).
  - Participation to the workshop on IoT Interoperability (held in parralel of the Berlin IETF meeting), an IERC meeting organised by the PROBE-IT project (http://www.probe-it.eu)

Note that two papers were published at the most selective and prestigious venues in networking – ACM SenSys and ACM/IEEE Infocom.

CALIPSO’s events

- CALIPSO workshop at FIA in Dublin (May 2013)

CALIPSO organized a half-day Pre FIA Workshop (in connection with the IERC cluster projects Butler, iCore, and IoT6) at the 2013 Future Internet Assembly (FIA) event, Dublin, Ireland, May 2013 (held in association with the Irish presidency of the Council of the EU). Presentations by Mischa Dohler \Sensors and Machine-to-Machine Technologies" and Andrzej Duda \All IP IoT solutions, where we are today?"

- Summer School on Internet of Things and Smart Cities

In order to provide an opportunity for the CALIPSO project to disseminate, in a coordinated and extensive way, the results of the CALIPSO project, UPA has taken the lead, with the support of all CALIPSO consortium, in the organization of the “Internet of Things and Smart Cities Ph.D. School 2013,” which will be held in Lerici (SP), Italy, between 16-21 September 2013.
The aim of the Ph.D. School is to address young researchers to the forefront of research activity on Internet of Things & Smart Cities, by presenting state-of-the-art research together with the current and future challenges in building smart cities in an efficient and sustainable way, in order to provide a thorough overview of the main topics about Internet of Things (IoT) and Smart Cities and their envisioned integration. International speakers from academia and industry will give lectures tailoring their research field for an interdisciplinary audience. A dedicated discussion panel will focus on the interaction and the collaboration between academia and industry in order to depict the future vision of Smart Cities and IoT. Participants will also have the opportunity to present their research activities during a dedicated session. The school will allow participants to be exposed to cutting edge results in one of the most challenging research area, while at the same time enjoying the relaxing atmosphere of one of the most beautiful Italian locations.
The Ph.D. school will allow the CALIPSO project to reach out and have interactions with other on-going projects. Namely, some of the non-CALIPSO speakers are involved in other EU projects and it envisioned that these interactions will likely lead to collaboration and further joining project proposals, which build on CALIPSO to further promote the integration of IoT with smart cities.
The audience included:

- post-graduate students, Ph.D. students, and young researchers from universities;
- researchers and engineers from academic and industrial laboratories around the world;
- people from industry who wish to discover the innovative applications of IoT, Smart Cities and sensor networks.

Summer School participants

The list of keynote speakers has been the following:

- Prof. Mischa Dohler, King's College London, United Kingdom, and WorldSensing, Spain (CALIPSO consortium);
- Prof. Andrzej Duda, INP-Ensimag Grenoble, France (CALIPSO consortium).

The lecturers are the following:

- Olivier Dupont, Cisco Systems, The Netherlands (CALIPSO consortium);
- Dr. Simon Duquennoy, Swedish Institute of Computer Science, Sweden (CALIPSO consortium);
- Prof. Luca Veltri, University of Parma, Italy (CALIPSO consortium);
- Claudio de Paoli, Bip.CyberSec;
- Dr Paolo Medagliani from Thales (CALIPSO consortium);
- Prof. Roberto Verdone and Dr. Chiara Buratti, University of Bologna, Italy;
- Dr. Christos Efstratiou, University of Cambridge, United Kingdom;
- Dr. Marius Monton, WorldSensing, Spain (CALIPSO consortium);
- Prof. Luis Munoz, Polytechnical University of Cataluna (UPC), Spain;
- Dr. Emilio Calvanese Strinati, Centre for Atomic Energy (CEA), Grenoble, France.

We remark that: Prof. Roberto Verdone and Dr. Chiara Buratti, both of the University of Bologna, are currently involved (as CNIT-Research Unit of Bologna) in the \Network of Excellence in Wireless COMmunications#" (NEWCOM#, http://www.newcom-project.eu/), Grant Agreement No. 318306; Prof. Luis Mu~noz (UPC, Spain) and Dr. Emilio Calvanese Strinati (CEA, France) are currently involved in the SmartSantander project on Future Internet Research & Experimentation, Grant agreement No. 257992. The SmartSantander project, by considering the application of IoT technologies to smart cities scenarios, is very synergistic with the main research activities of CALIPSO and with the school topic.

The School will also feature two sessions:

- Hands on Contiki OS and Cooja Simulator," given by Dr. Simon Duquennoy (SICS) and Pietro Gonizzi (UPA);

- Hands on CoAP and Service Discovery," given by Dr. Simone Cirani (UPA) and Dr. Marco Picone (UPA).

The goal of these \hands on" sessions is to allow the participant PhD students to develop and present project ideas (in the last day of the school).

Finally, the school will also feature and Industry and Academia Panel Session. In particular, the industrial participants were: CISCO (Netherlands), Guglielmo (Italy), Thales Communication and Security (France), WorldSensing (Spain), Selex-ES (Italy), AT&T (USA), BIP CyberSEC (Italy).

Talks and Presentations

The main talks/presentations related to CALIPSO's activities (either presentation of the CALIPSO's project itself or on topics strictly related to the research activities carried out within CALIPSO) can be summarized as follows.

- IoT Week 2013, June 2013, Helsinki, Finland. Paolo Medagliani (TCS), presented the activities of CALIPSO (through a talk entitled "Challenges in Future Smart Cities Services") in the Panel Session "IoT for Smart City."
- IERC AC1 meeting (IOT architectures), November 2012, at SAP Research premises, Regensdorf (Zurich), Switzerland. The activities of CALIPSO were presented by Andrzej Duda (CNRS) and Vladimir Vukadinovic (DRZ).
- Presentation by Mischa Dohler, within the IEEE ComSoc Distinguished Lectureship Tour China, on "Machine-to-Machine - Standards, Technologies, Applications," @ Shenzhen ComSoc Chapter, July 2012.
- IoT Week 2012, June 2012, Venice, Italy. Gianluigi Ferrari (UPA) presented the project CALIPSO at the IERC panel on IPv6 (within the session IoT and IPv6, http://www.iot-week.eu/iot-week-2012/programme-1/wednesday-1/ipv6-and-iot).
- Workshop on IoT Interoperability (held in parralel of the IETF meeting), an IERC meeting organised by the PROBE-IT project (http://www.probe-it.eu/?p=183), Paris, France, March 2012. Jérémie Leguay presented CALIPSO.
- Participation of CNRS in the 1st 6LoWPAN Interop event (Plugtests) co-located with the 87th IETF meeting (28 July - 02 August 2013) in Berlin, Germany. The event was supported by IPSO Alliance, FP7 PROBE-IT and IPV6 Forum. Interoperability tests of the Calipso Contiki based stack.

Standardization activities

- IETF
    - Participation by CISCO, WOS, TCS, CNRS and SICS to the 87th IETF meeting in Sophia Berlin (29th July to 2nd August October 2013)
- Participation of Cisco to the IPSO Alliance: Smart Energy committee

New IETF group on 6TSCH

Low power and Lossy Networks (LLNs) interconnect a possibly large number of resourceconstrained nodes to form a wireless mesh network. The 6LoWPAN, ROLL and CoRE IETF Working Groups have defined protocols at various layers of the LLN protocol stack, including an IPv6 adaptation layer, a routing protocol and a web transfer protocol. This protocol stack has been used with IEEE802.15.4 low-power radios.

The IEEE802.15.4e Timeslotted Channel Hopping (TSCH) [1] is a recent amendment to the Medium Access Control portion of the IEEE802.15.4 standard. It inherits from long-standing industrial process control standards such as WirelessHART and ISA100.11a, while significantly improving reliability, determinism, and power consumption.

The nodes in a IEEE802.15.4e TSCH network communicate by following a TDMA schedule. A timeslot in this schedule provides a unit of bandwidth that is allocated for communication between neighbor nodes. The allocation can be programmed such that the predictable transmission pattern matches the traffic. This avoids idle listening, and extends battery lifetime for constrained nodes. Channel-hopping improves reliability in front of narrow-band interference and multi-path fading.

These techniques enable a new range of use cases for LLNs, including:

- Control loops in a wireless process control network, in which high reliability and a fully deterministic behavior are required.
- Umbrella networks transporting data from different independent clients, and for which an operator needs flow isolation and traffic shaping.
- Energy harvesting networks, which require an extremely low and predictable average power consumption.

IEEE802.15.4e only defines the link-layer mechanisms. It does not define how the network communication schedule is built and matched to the traffic requirements of the network. The IETF 6TSCH Working Group will focus on enabling IPv6 over the TSCH mode of the IEEE802.15.4e standard. The scope of the WG includes one or more LLNs, each one connected to a backbone through one or more BackBone Routers (BBRs). Initially, the WG will consider a framework to install a static schedule. In this case, a node’s schedule remains unchanged after the node is done joining a network. The Routing Protocol for LLNs (RPL) is used on the resulting network. If successful, the intent is to recharter to allow for dynamic schedules. For example, an entity located on the backbone can centrally compute a dynamic schedule for traffic to be switched by the timeslot sublayer. Alternatively, the amount of timeslots scheduled between two neighbors may be adapted dynamically to the amount of traffic routed between those two nodes. The WG will interface with other IETF WGs, potentially including ROLL, 6Lo, CoRE, 6MAN, LWIG, and other appropriate groups in the IETF Internet, Routing and Security areas.

Contribution to the new IETF group 6lo

IPv6 over networks of resource-constrained nodes (6lo) a proposed working group that focuses on IP-over-foo standardization (adaptation layers) for constrained node networks, working closely with the INT area working groups and other IETF WGs focused on constrained node networks. 6lo is needed to continue the work started in 6LoWPAN working group that has completed its charter and now closed for further contribution.

6Lo focuses on INT area work that is needed for constrained node networks. Specifically, it is working on:

- Adaptation layer specifications for link layer technologies of interest in constrained node Networks
  Related MIBs
- Common infrastructure specification such as header compression specific to constrained node networks
- Maintenance and informational documents required for the existing IETF specifications in this space.

Open source strategy and organisation

One of the goals of CALIPSO is to contribute to the sensor networking community through the release of open source software and contributions to the Contiki OS. To this end, we have created a public github project (https://github.com/sics-iot/calipso) that gathers contributions from all partners. The repository has one top-level directory for every contribution. Each contribution includes a README file, that summarizes a number of important information, namely: a short description, a contact person, the author list and affiliations, the chosen license, the contiki version, intended CALIPSO scenario and hardware platform, the tested hardware platforms and environment. Regarding the hosting of the actual code, we offer two options: (1) directly hosting the code in the directory of the contribution, next to its readme file; (2) linking to an external directory.

In addition to this public github repository, we created a private one (https://github.com/sics-iot/calipso-private), working along the same principles. The private repository is used for code that can not be disseminated (or not yet) as open source, due to possible pending patent or other reasons.

Open source realeases in the Contiki community

Open Source contributions have already been performed within the CALIPSO project on the following topics:

- RPL
- ORPL
- IKEv2
- CoAPs Lithe
- SVELTE
- Multi-Hop PSM for 802.11
- Caching proxy

3.2.3 Major achievements and next steps

The major achievements of the work package are:

- Periodic update of the CALIPSO web site with events, publications and use cases
- Preparation and delivery of D2.231 “Market Analysis and Exploitation Plan” (M18)
- Preparation and delivery of D2.241 “Dissemination and Standardisation Report” (M24)
- Participation to IERC activities (project portfolio, requirements sharing, presentations at cluster meetings)
- Presentation and scientific publications
- Review and planning of standardization activities

3.2.4 Deviation and corrective actions

The project has been very active at disseminating project results leading to a high number of publications, a few open source releases and participations to standardisation groups. The next year will be further dedicated to implementations and testing. This should lead to more open source releases and a confirmed activity in IETF.

3.3 Integrated Architecture: use cases, requirements, and specifications

WP3			Start date		Month 1		
Leader:	CNRS		**End Date:**		Month 30		
Participants		TCS	**CNRS**	SICS	UPA	DRZ	WOS	Cisco
Resources (PMs)	**Planned**	8	9	7	4	8	13	4
	Actual	9,35	9,14	6,52	4,55	8	13,80	1,90

3.3.1 Objectives of the Work Package

The objectives of this workpackage pertain to identifying the application scenarios, use cases, and requirements that influence the approach proposed by CALIPSO. With the use cases and requirements at hand, an integrated CALIPSO architecture will be designed and technical specifications will be derived to guide further technical development in subsequent workpackages. This can be summarised in the following set of high-level objectives:

- to define the details of application scenarios and use cases influencing the CALIPSO protocol stack.
- to define the requirements for the CALIPSO integrated stack.
- to identify the enhancements required to the standard IP stack to operate in networks of Smart Objects
- to specify the interactions between layers and interfaces of the integrated protocol stack.

This work package is composed of the following tasks:

- Task 3.1 [Lead DRZ] – CALIPSO application scenarios.
- Task 3.2 [Lead CNRS] – Requirements for the CALIPSO integrated architecture.
- Task 3.3 [Lead TCF] – Design of CALIPSO architecture and enhancements to the IP stack.

3.3.2 Tasks addressed during the period

During the reporting period, the following actions were carried out within the different tasks of the work package to satisfy the success criteria:

- Refinement of the architecture based on the review results.
    - Analysis of interactions between CALIPSO's modules
    - Define the variant of the CALIPSO architecture for each use case scenario
    - Discussion on the experimentations
    - Mapping between functionalities and experimentations
    - Positioning of WP4/WP5 contributions in the overall architecture
    - Reconsideration of the architecture for the upcoming deliverables of WP4 and WP5

- Preparation of D3.321 “Integrated architecture with proposed mechanisms” (M18) deliverable following the review recommendations.
- Preparation of D3.322 “Integrated architecture with proposed mechanisms” (M24) Deliverable (M24)

3.3.3 Major achievements and next steps

The major achievements of the work package are:

- D3.321 “Integrated architecture with proposed mechanisms” (M18)
- D3.322 “Integrated architecture with proposed mechanisms” (M24)

The next steps planned for the WP are:

- Coordination of the work of WP6 for the first development and implementation phases according to the architecture.
- Preparation of D3.33: (Month 30) “Final architecture”

3.3.4 Key results

See publishable summary.

3.3.5 Deviation and corrective actions

We have delivered two deliverables on the architecture: requested by the reviewers, D3.321 presented the refined architecture, the answers to the comments of the experts, and the preliminary results of WP4 and WP5. The architecture included the mapping of the planned testbeds to the variants of the architecture that will be involved in each use case. D3.322 presented further refinement of the architecture. The detailed mechanisms developed in WP4 and WP5 are reported in respective deliverables of WP4 and WP5.

3.4 WP4 - Bringing IP-connectivity into Smart Objects

WP4				**Start date**	Month 8		
Leader:	SICS			**End Date:**	Month 26		
Participants		TCS	CNRS	**SICS**	UPA	DRZ	WOS	Cisco
Resources (PMs)	**Planned**	6	19	11	12	4	12	4
	Actual	6,45	19,09	11,00	13,09	8,50	14,40	1,40

3.4.1 Objectives of the Work Package

This work package aims at optimizing and enhancing IP-enabled networking over duty-cycled and lossy links as well as defining new mechanisms and support required by target applications such as mobility. Efficient routing and forwarding is at the core of this WP: the project proposes first to enhance MAC–IP integration by considering how RPL routing can efficiently use duty-cycled MAC layers. It will also analyse how mobility impacts RPL routing and propose required enhancements. Then, we will analyse RPL objective functions and metrics and defined advanced metrics for most common radio PHY layers as well as objective functions that take into account energy savings and security. Moreover, the project will design new protocols for data aggregation and data centric communications.

This work package is composed of the following tasks:

- Task 4.1 [Lead UPA] – Low power MAC integration.
- Task 4.2 [Lead SICS] – ROLL routing and RPL metrics.
- Task 4.3 [Lead CNRS] – Data aggregation and data centric communications.

3.4.2 Tasks addressed during the period

During the reporting period, the following actions were carried out within the different tasks of the work package to satisfy the success criteria:

- Task 4.1: Low-power MAC integration
    - Work on the interaction between L2 (802.15.4) and L3 (RPL routing) (TCS and UPA)
    - Continuation of the work on the interaction between L2 (802.15.4) and L3 (RPL routing) (CNRS)
        - Evaluation of the Beacon Enabled mode for low power operation.
        - Design and evaluation of the adaptive IEEE 802.15.4 MAC for throughput and energy optimization.
        - Design of Wake-on-Idle, a mechanism for maintaining the neighborhood in an energy efficient way.

        - Design of Sleep-on-Idle, a mechanism for energy savings in 802.15.4 multi-hop networks.
    - Proposal of a mechanism to reduce duty cycling by using a technique that estimates clock drift (WOS)
    - Work on duty-cycling in 802.11 (DRZ):
        - Proposed an enhanced power save mode (MH-PSM) for low-latency multi-hop communication in 802.11 networks
        - Implemented MH-PSM in a simulator and evaluated its performance against the standard 802.11 PSM
        - Created a flexible Contiki-based open-source platform for experimentation with MAC layer management functions in 802.11
        - Implemented MH-PSM as a part of a Contiki driver for Atheros AR9170 Wi-Fi chipset
        - Experimentally evaluated MH-PSM and compared its performance to the standard 801.11 PSM
    - Implementation of infrastructure-less 802.11 power save mode (PSM) in Jemula simulator
        - Simulation study of PSM performance in ad hoc mobile scenarios (Smart Toys in a park)
        - Implementing 802.11 U-MAC on Contiki, including PSM (duty-cycling) for ad hoc mode
        - Standard PSM and MH-PSM evaluation (indoor), preparation for outdoor measurements
        - Practical implementation of the multi-hop PSM (MH-PSM) published at iThings
    - Continue with the proposal of a scheduler over TDMA by using MPLS. (WOS)
    - RPL and ContikiMAC: interplay, link estimation, evaluation in Twist (SICS)
    - Multi-channel ContikiMAC (SICS)
        - Implementation and cooja evaluation of a multi-channel version of contikimac
    - Testbed evaluation of the multi-channel ContikiMAC
- Task 4.2: ROLL routing and RPL metrics
    - Experimental study of RPL routing over 802.15.4 networks and evaluation of L2 metrics for RPL
    - Design of a lightweight routing protocol for LLNs by CNRS
    - Opportunistic routing in RPL, based on anycast, contikimac and bloom filters (SICS)
        - Design of ORPL
        - Implementation in Contiki
        - Evaluation and comparison against RPL, in the Indriya testbed 135 nodes over 3 floors in a Singapore building
        - Paper accepted at ACM SenSys 2013

- Review of the role of sensor networks in Cyber-physical Systems, and overview of current IP-based academic solutions, available implementations, and applications (SICS)
- Energy efficiency and delay efficiency optimization of the RPL objective function (UPA)
- Internal meetings and Research on RPL scalability (CISCO)
- ContikiMAC Phase Synchronization through RPL (UPA)
- Analysis of issues with mobility support in RPL (UPA)
- Performance comparison of the RPL and LOADng routing protocols in a Home Automation scenario (CNRS)
- Design of a lightweight routing protocol for LLNs (CNRS)

- Task 4.3: Data aggregation and data centric communication (to be updated)
  - TCF-UPA collaboration on a protocol for in-network storage
  - Distributed data storage with SensLab experimental validation of analytical framework (UPA)
  - Distributed data storage and retrieval with RPL and no duty cycling (UPA)
  - Investigation of a datacast primitive for in-network processing and data aggregation (CNRS)
  - Design of RAWMAC, an Advanced Cross-layer Data Collection Protocol (CNRS)
  - Evaluation of data aggregation techniques for the Smart Parking use (WOS)

3.4.3 Major achievements and next steps

The major achievements of this work package are:

- Execution of planned technical work on low-power MAC, routing, and data-centric communication
- Publication of 19 referred papers in prestigious journals and conferences
- Our IETF draft reporting on performance evaluation of RPL had become Informational RFC6687
- Contribution to the Contiki OS, mostly regarding the implementation of RPL and neighbor management (core redesign, updates, and fixes)
- Writing of the three WP4 deliverables, D4.41, D4.42, and D4.43, reporting on WP4 technical activities

The second year marks the end of this work package. Third year will be dedicated to dissemination and field experimentation of the techniques we developed.

3.4.4 Key results

The consortium has first investigated issues related to low-power IP connectivity in the context of the CALIPSO application scenarios.

We have devised a number of technical solutions, at the MAC, routing layer, and at the interaction between both.

Our resulted in publications in 19 peer-reviewed, prestigious journals and conferences. Reference numbers are the one of WP2.

Task 4.1: Low-power MAC integration

This task investigates the interaction between duty-cycled (low-power) MAC layers and the RPL (routing) protocol. In order to address the needs of the different CALIPSO applications, we worked on different duty-cycled MAC layers, namely 802.15.4 Beacon-Enabled, 802.15.4 with low-power listening (ContikiMAC), 802.15.4e Time Synchronized Channel Hoping (TSCH), and 802.11 Power Saving Mode (PSM).

802.15.4 Beacon-Enabled

We propose a neighborhood maintenance mechanism called Wake on Idle (WoI) that allows keeping connectivity between energy-constrained sensor nodes [27]. We apply the approach based on Idle Sense (802.11) to 802.15.4 Beacon-Enabled networks, finding the right balance between the time spent in backoffs and collisions to maximize throughput [24].

We also have to contributions that are submitted for publication, on (1) Sleep on Idle, a mechanism that strikes good tradeoffs between reactivity and energy, and on (2) the Multi-Channel Beacon Train protocol for fast an energy-efficient topology construction in multi hop 802.15.4 Beacon-Enabled networks.

802.15.4e TSCH

We propose a clock drift compensation mechanism for 802.15.4e TSCH. We have developed a simple adaptive synchronization technique that can either reduce the keep-alive interval, or shorten the guard time [4]. We apply RSVP-TE to manage the schedule in a IEEE802.15.4e network at layer 2.5 and install LSPs to connect sensor nodes in the network [13].

802.15.4 Low-power Listening

We propose a multi-channel extension to the ContikiMAC duty cycling protocol. We show that a simple channel hopping approach provides substantial gains in reliability, latency, and energy. This work resulted in a Master thesis report by Beshr Al Nahas. We plan to perform a testbed evaluation and publish the results.

802.11 PSM

We consider the problem of energy consumption in 802.11 networks that can be used for radio-enabled toys. We propose a mechanism that extends the Power-Saving Mode (PSM) by waking up downstream stations so that data frames can be forwarded over multiple hops in a single beacon interval [19].

Task 4.2: ROLL routing and RPL metrics

This task focuses on RPL routing optimization in duty-cycled environment.

Interaction between RPL and low-power MAC layers

We first investigate in a link quality estimation, which we have identified in Task 4.1 as

a critical component for routing over duty-cycled links [18].

We extend RPL with the opportunistic routing approach. We demonstrate the benefits of our approach in robustness, delay and energy through an extensive testbed evaluation, encompassing various scenarios and traffic patterns [29,16].

We have two contributions currently under submission, (1) on RAWMAC, a phase synchronization mechanism for low-power listening MAC layers, and (2) on the integration of 80215.4 Beacon-enabled cluster-tree topology and RPL's DODAG topology.

RPL enhancements and performance evaluation

We introduce new routing metrics for RPL, in addition to the traditional ETX and hop count, aiming at optimizing either for low-delay or low-energy paths [22]. We evaluate RPL against LoadNG, a proactive routing protocol for low-power and lossy networks. We find that RPL offers better performance in delay and hop count, at the price of higher implementation complexity than LoadNG [26].

We propose new routing enhancements for Low Power and Lossy Networks: first, a link reversal for RPL, and second, an hybrid routing protocol that is both proactive (based on RPL) and reactive (based on LoadNG). Our evaluation demonstrates benefits in convergence time, which also reduces the time and cost of link failure recovery, which is an important property for robustness [34].

Finally, we also conducted a yet unpublished preliminary evaluation of RPL in mobile environment, which is particularly useful in the Smart Toys application scenario.

Task 4.3: Data aggregation and data centric communication

This task investigates how to apply the concepts of data aggregation and data-centric communication to IP-based sensor networks, and proposes new solutions for data collection over duty-cycled MACs.

Data-centric communication

We propose a redundant distributed data storage and retrieval mechanism to increase the resilience and storage capacity of a RPL-based WSN against local memory shortage. Results show that RPL can be used for robust and energy-efficient distributed data storage and retrieval [20].

We present Datacast, a new communication primitive that provides support for in-network processing and aggregation of sensor data. The presented work is preliminary, not yet published, and subject to on-going work of evaluation.

Duty-cycled data collection

We present the Hybrid Data Collection Protocol (HDCP) that addresses the problem of transferring data from some intended sources to a given sink over the RAWMAC layer. In HDCP, we align the wakeup schedule of nodes along the path towards the network sink, aiming at minimizing delay.

Data aggregation

We propose a study of data aggregation in standard-based low-power networks, in the context of the WOS smart parking application scenario. Our conclusion (reported on in D3.2, section 7.9 and D4.3, section 3.1) was that the only relevant type of aggregation in this scenario was hop-by-hop aggregation, which breaks the layered IP stack. For this reason, we decided to pursue work in this direction. WOS has instead focused on a more critical aspect for the smart parking scenario, that of enhancing 802.15.4e TSCH and its interaction with RPL (Task 4.1).

3.4.5 Deviation and corrective actions

An important component of Task 4.3 was initially data aggregation, especially for the smart parking application scenario with WOS.

A preliminary study (reported on in D3.321, section 7.9 and D4.43, section 3.1) showed that data aggregation in the smart parking scenario needed to be hop-by-hop, which breaks the layered model of the IP stack. WOS has re-focused its effort on 802.15.4e TSCH time synchronization and scheduling (Task 4.1), an aspect that turned out to be very important in the smart parking application.

DRZ has also move its effort on mobility from WP5 to WP4.

3.5 WP5 - Enhanced transport and service layers

WP5				**Start date**	Month 8			
Leader:	UPA			**End Date:**	Month 26			
Participants		TCS	CNRS	SICS	**UPA**	DRZ	WOS	Cisco
Resources (PMs)	**Planned**	17	3	10	10	6	0	0
	Actual	15,00	3,05	10,00	11,01	1,00	0,0	0,0

3.5.1 Objectives of the Work Package

This work package aims at enhancing and adapting the transport and application layers. The project proposes to analyse transport protocols and their behaviour over duty cycled MAC layers. Our goal is to develop a new protocol over UDP oriented towards low power data streaming. The project aims at enhancing CoAP and 6LowApp upcoming developments with respect to performance and robustness. Large-scale service discovery mechanisms, supporting a large number of distributed objects, have been investigated. Finally, WP5 original goals included the support for mobility and security to meet the application requirements defined in WP3.

This work package is composed of the following tasks:

- Task 5.1 [Lead TCF] – Transport adaptation and data-centric support.
- Task 5.2 [Lead TCF] – Secure and large-scale service discovery.
- Task 5.3 [Lead DRZ] – Mobility and security support.

3.5.2 Tasks addressed during the period

During the reporting period, the following actions were carried out within the different tasks of the work package:

- Task 5.1: Transport adaptation and data-centric support
  - Design and evaluation of a HTTP/CoAP proxy and caching system (TCS)

1 Implementation of a proxy node with caching capabilities (using Couch DB)

2 Translation of HTTP requests into CoAP requests and vice versa

  - Design of a data-centric scheme oriented towards in-network processing and featurecast. (CNRS)
  - Analysis of the performance of TCP with radio duty cycling (UPA)
- Task 5.2: Secure and large-scale service discovery
  - Application of OAuth authorization protocol to CoAP (UPA)
  - Design and implementation of CoSIP, a session management protocol for constrained nodes (UPA)
  - Design and implementation of 6LowPAN compression for DTLS protocol (SICS)
    1. Implementation of the DTLS header compression scheme in Contiki OS

  - Implementation of certificate-based authentication for DTLS with novel techniques (SICS)
  - Design and Implementation of a Service discovery mechanism for CoAP using Zero Configuration protocol (UPA and TCS)
- Task 5.3: Mobility and security support
  - Study of routing attacks and countermeasures for RPL and 6LowPAN (SICS)
  - Design, implementation and evaluation of a real-time intrusion detection system for IoT (SICS)
  - Design of a group key distribution protocol for secure distribution of symmetric cryptographic keys (UPA)
  - Study of lightweight security algorithms for IPv6 and IoT (UPA).
  - Design and evaluation of a distributed key verification protocol (CNRS)
  - IETF draft on IPsec header compression submitted http://tools.ietf.org/html/draft-raza-6lowpan-ipsec-00 (SICS)

3.5.3 Major achievements and next steps

The major achievements of the work package are:

- Execution of planned technical work on transport adaptation, service discovery, and security support
- D5.51 “Transport adaptation and data-centric support” (M24)
- D5.52 “Secure and large-scale service discovery” (M24)
- D5.53 “Mobility and security support” (M24)
- 9 scientific publications, 1 submitted IETF draft
- Contribution to the Contiki OS, mostly regarding the implementation of DTLS, IKEv2 and IPsec 6LowPAN compression

The second year marks the end of this work package. Third year will be dedicated to dissemination and field experimentation of the techniques we developed.

3.5.4 Key results

The consortium has first investigated issues related to transport and service layers in the context of the CALIPSO application scenarios.
We have devised a number of technical solutions at the application layer, at security, and at the interaction between both.
Our work resulted in publications in 9 peer-reviewed, prestigious journals and conferences, and a submitted IETF draft. Reference numbers are the ones of WP2.

Task 5.1: Transport adaptation and data-centric support

This task aims at adapting the transport layer protocols to duty-cycled MAC and to explore data centric approaches to communication using publish/subscribe paradigm.

HTTP/CoAP Proxy

We have proposed a solution for proxing data between a CoAP network and a HTTP network. In order to avoid useless communications from a constrained wireless network, we have implemented a caching system. An optimization strategy to carefully choose the lifetime duration of cached data has also been presented.
This work was presented at Sensornets 2013 conference [30].

Data-centric Protocol Featurecast

We have introduced Featurecast, a data-centric protocol to efficiently handle one-to-many communications. In particular, Featurecast allows to dispatch information to all the devices sharing the same set of characteristics of interest. This approach is totally distributed since the addresses used for data routing are self-determined by the nodes, without requiring a central coordinator that orchestrates route creation.
This work has been submitted for publication.

Task 5.2: Secure and large-scale service discovery

This task focuses on the secure and large-scale service discovery for smart objects.

Application of OAuth authorization protocol to CoAP

We have introduced an authentication service for smart objects that relieves the constrained nodes from implementing and handling the authentication procedure. All the required operations are delegated to an external trusted node which authorizes the user issuing a token.

CoAP and CoSIP

We have introduced CoSIP, a session management protocol for constrained networks based on UDP. Unlike CoAP, CoSIP first negotiates the session parameters and then performs a lighter communication using the above mentioned parameters. This work has been presented at the CLIoT 2013 workshop [CoSIP].

Lightweight Secure CoAP for the Internet of Things

We have propose 6LoWPAN compressed DTLS, enabling lightweight CoAP support for the IoT. The DTLS header compression has been implemented in the Contiki OS. This work has been published into the IEEE Sensors journal [3].

Certificate-based Authentication for the Web of Things

We have designed a certificate-based authentication system for IoT. This mechanism reduces the transmission overhead for session setup and resumption, in order to decentralize large part of the computation operations to more powerful devices and reduce the amount of exchanged control data. This work has been presented at the HotWiSec workshop [23].

A peer-to-peer overlay for service discovery

We have investigated the use of a peer-to-peer (p2p) overlay network to implement a service discovery mechanism for large scale networks. Users can contact the service discovery to retrieve the list of resources in a given area of interest. This system easily scales when the network dimension increases.

<u>Task 5.3: Mobility and security support</u>

This task aims to evaluate and optimize the LLC routing protocols for scenarios where smart object are highly mobile and to develop IP security mechanisms for data centric communication, including secure aggregation of encrypted data.

Analysis of network, transport, and application layer security mechanisms for 6LoWPAN

We have carried out an extensive review of network, transport, and application layer security protocols that are the most commonly used for securing IP-based end-to-end communications between smart objects. This activity has led to the work published in [9].

Routing Attacks and Countermeasures in the RPL-based Networks

We have studied how RPL routing protocol behaves in the presence of some of the most common routing attacks in 6LoWPAN networks. Moreover, we have also investigated how security features in IPv6 can be used for intrusion detection or exploited by the attackers.

This work has been published in the International Journal of Distributed Sensor Networks [1].

Real-time Intrusion Detection in the Internet of Things

We have designed, implemented, and evaluated SVELTE, a novel Intrusion Detection system specifically designed for the IoT. It primarily targets routing attacks, but it is extensible and can be used to detect other attacks.

This work has been published in the Ad Hoc Networks journal [8].

Compression of IPsec AH and ESP Headers for Constrained Environments

We have introduced a header compression mechanisms for the IPsec, which is compliant with the 6LoWPAN header encoding scheme standardized in RFC 6282.

The work has been published as an IETF Internet Draft [IETF draft].

Secure distribution of shared keys

We have presented a group key distribution protocol for secure distribution of symmetric cryptographic keys. The protocol is tailored for very dynamic ad-hoc networks, either wired or wireless. It provides proper mechanisms to deal with unpredictable leave events and to resist against collusive attacks.

This work has been published in the Ad Hoc Networks journal [5].

Distributed key verification and management

We have proposed a distributed key verification protocol that does not require certification authorities and certificates. Under this protocol, nodes autonomously verify the authenticity of public keys they exchange using one-way accumulators.
This work has been submitted for publication.

3.5.5 Deviation and corrective actions

With respect to the original work plan, the following deviations can be summarized. For each deviation, the corresponding corrective action is described.

In Task 5.1, one of the originally planned activities included the design a new protocol over UDP for robust low power data streaming with guarantees in latency and packet loss. In this case, rather than considering a new protocol on top of UDP, a new application layer protocol, named CoSIP, has been defined to allow the instantiation of sessions among smart objects.

In Task 5.2, one of the planned activities was related to the design of robust routing protocols for seamless IP connectivity in the presence of mobile smart objects. This has been considered in T4.2, where the impact of mobility (in terms of network connectivity in LLNs) has been investigated.

In Task 5.3, we proposed to study secure data aggregation of encrypted data. This activity has been actually investigated in T4.3, where it is shown that the processing cost does not warrant its applicability, especially at the light of experimental activities foreseen in WP6 (year 3 of the project).

3.6 WP6 - Experimental validation with target applications

WP6				**Start date**		Month 24	
Leader:	DRZ			**End Date:**		Month 36	
Participants		TCS	CNRS	SICS	UPA	**DRZ**	WOS	Cisco
Resources (PMs)	**Planned**	5	6	3	3	14	20	0
	Actual	0,5	0	0	0	1,0	0,56	0

3.6.1 Objectives of the Work Package

The objectives of this work package concern integration, validation and experimental evaluation of the CALIPSO stack. We will provide an ultimate proof of the viability of the new architecture. The ability to verify the stack through an implementation and to deploy it in real-world applications is crucial for that purpose.

The main objectives are to:

- integrate all protocols/mechanisms on testbeds
- evaluate each proposed protocol/mechanism and validate the global integration
- develop benchmarks and performance indicators for the experimental evaluation
- deploy the protocol stack in two real-world applications and perform trials
- identify missing aspects and issues for further improvement.

This work package is composed of the following tasks:

- Task 6.1 [Lead WOS] – Integration and validation of the CALIPSO stack.
- Task 6.2 [Lead DRZ] – Experiments and showcases.

3.6.2 Tasks addressed during the period

During the reporting period, the following actions were carried out within the different tasks of the work package:

- Preparation of preliminary demonstrators for the review

4 Deliverables and milestones tables

Deliverables (excluding the periodic and final reports)

TABLE 1. DELIVERABLES

Del. no.	Deliverable name	WP no.	Lead participant	Nature	Dissemination level	Due delivery date from Annex I	Delivered Yes/No	Actual / Forecast delivery date	Comments
D2.231	Market Analysis and Exploitation Plan	WP2	TCS	R	RE	M18	Yes	March 11th 2013	
D3.321	Integrated architecture with proposed mechanisms	WP3	CNRS	R	RE	M18	Yes	March 11th 2013	
D4.41	Protocols for low power MAC–IP integration	WP4	UPA	R	RE	M22	Yes	July 9th 2013	
D4.42	Enhancements to ROLL routing and RPL	WP4	SICS	R	RE	M22	Yes	July 9th 2013	
D2.241	Dissemination and Standardisation Report	WP2	UPA	R	RE	M24	Yes	Sept 18th 2013	
D3.322	Integrated architecture with proposed mechanisms	WP3	CNRS	R	RE	M24	Yes	Sept 18th 2013	
D4.43	Protocols for data aggregation and data centric communications	WP4	CNRS	R	PU	M24	Yes	Sept 18th 2013	
D5.51	Transport adaptation and data-centric support	WP5	TCS	R	RE	M24	Yes	Sept 18th 2013	
D5.52	Secure and large-scale service discovery	WP5	TCS	R	RE	M24	Yes	Sept 18th 2013	
D5.53	Mobility and security support	WP5	DRZ	R	PU	M24	Yes	Sept 18th 2013	

Milestones

TABLE 2. MILESTONES					
Milestone no.	**Milestone name**	**Due achievement date from Annex I**	**Achieved Yes/No**	**Actual / Forecast achievement date**	**Comments**
M4	Market analysis and exploitation plan delivered.	M18	Yes	M18	D2.231 has been delivered

5 Explanation of the use of the resources

This section provides an explanation of personnel costs, subcontracting and any major costs incurred by each beneficiary, such as the purchase of important equipment, travel costs, large consumable items, etc. linking them to work packages.

Please not that all figures in the rest of the document are estimations (i.e., non audited figures).

PERSONNEL, SUBCONTRACTING AND OTHER MAJOR COST ITEMS FOR TCS FOR THE PERIOD			
Work Package	Item description	Amount	Explanations
1,2,3,4,5	Personnel costs	170,966	WP1: project management (2.5 PM) WP2: market assessment for Smart infrastructure (2.4 PM) WP3: architecture work (2.55PM) WP4: data centric communication (replication) (5.64PM) WP5: protocol adaptation and service discovery(11.40PM) Total 24,6PM of efforts from 1 PhD student, 1 Engineer and 1 program manager.
	Subcontracting	0	
1,2,3,4,5	Travel costs	11,221	- Project review meeting in Brussels - October 10th, 2012. Attendees: J. Leguay, P. Medagliani, S. Raynaud - 5th plenary meeting in Parma - November 5th and 6th 2012. Attendees: J. Leguay, P. Medagliani - 6th plenary meeting in Grenoble - February 21th and 22nd 2013. Attendees: J. Leguay, P. Medagliani - Participation of R. Leone to SensorNets in Barcelona, Spain, February 2013 - Participation of Paolo Medagliani to the CALIPSO FIA Workshop in Dublin, Ireland, May 2013 - 7th plenary meeting in Barcelona - June 6th and 7th 2013. Attendees: J. Leguay, P. Medagliani - Participation of R.Leone, P. Medagliani, and J. Leguay to AlgoTel 2013, Pornic, France, May 2013 - IoT Week 2013, June 2013, Helsinki, Finland. Paolo Medagliani (TCS), presented the activities of CALIPSO (through a talk entitled “Challenges in Future Smart Cities Services”) in the Panel Session “IoT for Smart City.” (930€) - Participation of Jeremie Leguay to IETF meeting in Berlin– July 2013
	Equipment	0	
	Remaining costs	0	
TOTAL DIRECT COSTS AS CLAIMED ON FORM C		182,187	

PERSONNEL, SUBCONTRACTING AND OTHER MAJOR COST ITEMS FOR CNRS FOR THE PERIOD

Work Package	Item description	Amount	Explanations
1,2,3,4,5	Personnel costs	161466€	Salary of two professors and two associate professor: WP1: project management (2.24 PM) WP2: dissemination (0.36 PM) WP3: architecture work (0.36PM) WP4: low-level mechanisms (15.86PM) WP5: featurecast and security (2.69PM) Total 21.51PM.
	Subcontracting	0	
	Travel costs	8407	Travel Duda to Brussels 21/11/12 Travel Alphand, Rousseau to Zurich 3/12/12 Travel Duda Regensdorf 14/12/12 Travel Rousseau Torino, 22/5/12 Travel Duda Dublin 2/5/12 Travel Alphand, Heusse to Barcelona 3/6/12 Travel Alphand, Duble Berlin 26/7/12
	Equipment	0	
	Remaining costs	0	
TOTAL DIRECT COSTS AS CLAIMED ON FORM C		169874	

PERSONNEL, SUBCONTRACTING AND OTHER MAJOR COST ITEMS FOR SICS FOR THE PERIOD

Work Package	Item description	Amount	Explanations
2,3,4,5	Personnel costs	114705	WP2: .72 PM, 4471 € WP3: .1 PM, 666 € WP4: 9.26 PM, 58867 € WP5: 9,85 PM 50701 €
	Subcontracting	0	
2,3,4,5	Travel costs	8080.00	Project meeting, Brussels, Belgium, Oct. 18-19, 2012, 1 attendee, 652€ Fifth Plenary meeting, Parma, Italy, Nov. 5-7, 2012, 2 attendees, 1298€ Robosense Winter School, Hammanet, Tunisia, Dec. 18-20, 2012, 1 attendee, 951€ EWSN conference, Gent, Belgium, Feb. 13-15, 2013, 1 attendee, 998€ Plenary meeting, Grenoble, France, Feb. 21-23, 2013, 1 attendee, 792€ WSN4DC Conference, Jamshoro, Pakistan, April 22-27, 2013, 1 attendee, 1282€ Iot Week 2013, Helsinki, Finland, June 15-21, 2013, 1 attendee, 1214€ IETF 87 meeting, Berlin, Germany, July 29-Aug. 1, 2013, 1 attendee, 893€
	Equipment		
	Remaining costs	1027.00	1 poster, 32€

			1 Courier service to Paris, 67€ 1 article publication charge, 928€ ("Routing attacks and countermeasures in the RPL-based Internet of Things", in International Journal of Distributed Sensor Networks, 2013.
TOTAL DIRECT COSTS AS CLAIMED ON FORM C		123812.00	

PERSONNEL, SUBCONTRACTING AND OTHER MAJOR COST ITEMS FOR UPA FOR THE PERIOD			
Work Package	Item description	Amount	Explanations
2,3,4,5	Personnel costs	98332.81	**WP2**: contribution to website, paper presentation at SENSORNETS 2012, Participation to dissemination activities (presentation of CALIPSO at IOT week In June 2012). PMs: 2.83. Cost: € 8,288.42. **WP3**: contribution to the CALIPSO architectural design, partecipation to skype calls and project meetings. PMs: 0.74. Cost: € 1,329.34. **WP4**: design of efficient MAC protocols, distributed data storage and retrieval mechanisms, impact of duty cycling on higher layer performance, RPL metric optimization, joint MAC and routing protocol design. PMs: 10.56. Cost: € 57,124.60. **WP5**: transport and service layer design, design of security mechanisms for IoT scenarios, design of efficient group key distribution, design of efficient service discovery mechanisms. PMs: 6.70. Cost: € 31,590.45.
	Subcontracting	0	
2,4,5	Travel costs	6672.92	* Participation of Pietro Gonizzi to the IoT week in Venice (Italy), with dissemination of CALIPSO results with other IoT EU projects' participants June. 19-21, 2012. Cost: € 149.65. WP2. The travel took formally place in year 1, but it was paid in year 2. * Participation of Luca Veltri to the third project meeting in Grenobles (France), Apr. 10-12, 2012. Presents activities of UPA related to WP5. Cost: € 776.43. WP5. The travel took formally place in year 1, but it was paid in year 2. It is indicated as cost in WP5 as the activities of Luca Veltri mostly focused on WP5. * Participation of Simone Cirani to the fourth project meeting in Stockolm (Sweden), Jun. 26-27, 2012. Presents activities of UPA related to WP5. Cost: € 830.02 WP5. The travel took formally place in year 1, but it was paid in year 2. It is indicated as cost in WP5 as the activities of Luca Veltri mostly focused on WP5. * Participation of Gianluigi Ferrari at the first project review meeting in Brussels (Belgium), Oct. 18-19, 2012. Presents the overall CALIPSO activities of WP5. Cost: € 625.54. WP5. It is indicated as cost in WP5 as UPA is WP5 leader and presented the summary of the first year activities in WP5. * Participation of Luca Veltri at the first project review meeting in Brussels (Belgium), Oct. 18-19, 2012. Cost: € 415.29. WP5. It is indicated as cost in WP5 as UPA is WP5 leader and presented the summary of the first year activities

			in WP5. * Participation of Gianluigi Ferrari to the fifth project meeting in Grenobles (France), Feb. 21-22, 2013. Coordinated the workshop on WP5. Cost: € 603.18. WP5. It is indicated as cost in WP5 as UPA (Gianluigi Ferrari) was responsible for the WP5 workshop within the meeting. * Participation of Pietro Gonizzi to the fifth project meeting in Grenoble (France), Feb. 21-22, 2013. Presents a contribution of UPA to WP4. Cost: € 93.21. WP4. It is indicated as cost in WP4 as the activities of Pietro Gonizzi mostly focused on WP4. * Participation of Luca Veltri to the fifth project meeting in Grenoble (France), Feb. 21-22, 2013. Presents a contribution of UPA to WP5. Cost: € 93.21. WP5. It is indicated as cost in WP5 as the activities of Luca Veltri mostly focused on WP5. * Participation of Gianluigi Ferrari to the sixth project meeting in Barcelona (Spain), Jun. 2-4, 2013. Coordinated the workshop on WP5. Cost: € 517.41. WP5. It is indicated as cost in WP5 as UPA (Gianluigi Ferrari) was responsible for the WP5 workshop within the meeting. * Participation of Pietro Gonizzi to the sixth project meeting in Barcelona (Spain), Jun. 2-4, 2013. Presents a contribution of UPA to WP4. Cost: € 371.75. WP4. It is indicated as cost in WP4 as the activities of Pietro Gonizzi mostly focused on WP4. * Participation of Simone Cirani to the sixth project meeting in Barcelona (Spain), Jun. 2-4, 2013. Presents a contribution of UPA to WP5. Cost: € 400.18. WP5. It is indicated as cost in WP5 as the activities of Simone Cirani mostly focused on WP5. * Participation of Pietro Gonizzi at the National (Italian) Telecommunication meeting GTTI 2013, to present an accepted paper, Jun. 24-25, 2013. The paper is P. Gonizzi, R. Monica, G. Ferrari, "Design and evaluation of a delay-efficient RPL routing metric," riunione annuale 2013 del Gruppo nazionale Telecomunicazioni e Teoria dell'Informazione (GTTI), Session on Telecommunication Networks, Ancona, Italy, June 2013, 6 pages. Cost: € 177.80. WP4. Travel and registration costs. It is indicated as cost in WP4 as the content of the presented paper pertains to WP4. * Participation of Pietro Gonizzi at IWCMC'13, to present two accepted papers, Jun. 30-Jul.3, 2013. The presented papers are: (1) P. Gonizzi, R. Monica, and G. Ferrari, ""Design and evaluation of a delay-efficient RPL routing metric,"" 9th International Wireless Communications & Mobile Computing Conference (IWCMC 2013), Cagliari-Sardinia, Italy, July 2013. (2) P. Gonizzi, G. Ferrari, P. Medagliani, and J. Leguay, ""Data storage and retrieval with RPL routing,"" 9th International Wireless Communications & Mobile Computing Conference (IWCMC 2013), Cagliari-Sardinia, Italy, July 2013." Cost: € 933.49. WP4. Travel and registration cost. It is indicated as cost in WP4 as the content of the presented papers pertain to WP4. * Participation of Simone Cirani at IWCMC'13, to present an accepted paper, Jun. 30-Jul.3, 2013. The presented paper is L. Veltri, S. Cirani, G. Ferrari, and S. Busanelli, ""Batch-based group key management with shared key derivation in

			the Internet of Things,"" 9th International Wireless Communications & Mobile Computing Conference (IWCMC 2013), Cagliari-Sardinia, Italy, July 2013." € 472.54. WP5. Travel cost. It is indicated as cost in WP5 as the content of the presented paper pertains to WP5. * Partecipation of Simone Cirani at the inaugural event of the EUWin testbed in Bologna (Italy), organized by the EU project NEWCOMM#, related to the activities of CALIPSO, July 8-9, 2013. UPA has been subsequently invited to become Associate Partner of NEWCOMM#." Cost: € 213.22. WP2. Travel and registration cost.
4,5	Equipment	148.31	Computer and monitor acquired in year 1 (cost: € 650). Amortized cost over the second year: € 108.33. Electronic material for the WSN testbed (formally acquired in September 2013, i.e., in year 3 of the project). Cost: € 39.98 .
2,5	Remaining costs	245.54	Publication costs for the paper: S. Cirani, G. Ferrari, and L. Veltri, "Enforcing security mechanisms in the IP-based Internet of Things: an algorithmic overview," Algorithms, Special Issue "Sensor Network," vol. 6, no. 2, pp. 197-226, 2013. doi:10.3390/a6020197. Cost: € 245.54.
TOTAL DIRECT COSTS AS CLAIMED ON FORM C		105399.58	

PERSONNEL, SUBCONTRACTING AND OTHER MAJOR COST ITEMS FOR DRZ FOR THE PERIOD			
Work Package	Item description	Amount	Explanations
2,3,4,6	Personnel costs	128'673	WP2: market assessment and exploitation plans for Smart Toys, conf. paper at IEEE iThings, journal paper in Ad Hoc Networks (under review) (2.9 PM) WP3: contributing to the CALIPSO architectural design for Smart Toys (0.7 PM) WP4: work on low-power 802.11 MAC (7.5 PM) WP6: work on demo for 2nd year review (1 PM) Total 12.1 PM of efforts from 1 postdoc and 1 senior researcher.
	Subcontracting	0	
2,3,4	Travel costs	4'408	- 1st year project review meeting in Brussels, October 10th 2012: V. Vukadinovic (686 eur) - 5th plenary meeting in Parma, November 5th 2012: V. Vukadinovic, G. Corbellini (753 eur) - 6th plenary meeting in Grenoble, February 21st 2013: V. Vukadinovic (353 eur) - Calipso meeting in Brussles, May 27, Stefan Mangold (128 eur) - 7th plenary meeting in Barcelona, June 6th 2013: V. Vukadinovic (542 eur)

			- presentation at the IEEE iThings in Beijing, August 22nd 2013: V. Vukadinovic (1946 eur)
	Equipment	3'149	- Arduino boards, battery packs, LCD shields, Wi-Fi adapters, powerbanks
	Remaining costs	0	
TOTAL DIRECT COSTS AS CLAIMED ON FORM C		136'230	

PERSONNEL, SUBCONTRACTING AND OTHER MAJOR COST ITEMS FOR WOS FOR THE PERIOD			
Work Package	Item description	Amount	Explanations
2,3,4,6	Personnel costs	74.116,00€	20,36 PM Approximate contribution to each work-package: WP2: 4,8 PM – 17.473,32€ WP3: 2,4 PM – 8.736,66€ WP4: 12,6 PM – 45.867,47€ WP6: 0,56 PM – 2.038,55€
	Subcontracting	0€	
2,3,4,6	Travel costs	742,91€	06/11/2011. Parma (M.Domingo): 457,98€ 28-29/11/2011. Brussels (I.Vilajosana): 284,93€
2,3,4,6	Equipment	11.254,22€	Material, electronic components
	Remaining costs	0€	
TOTAL DIRECT COSTS AS CLAIMED ON FORM C		137.781,00€	

PERSONNEL, SUBCONTRACTING AND OTHER MAJOR COST ITEMS FOR CISCO FOR THE PERIOD			
Work Package	Item description	Amount	Explanations
WP2,3,4	Personnel costs	20,225	**WP2 -> 1 PM** Dissemination, Standardization and Exploitation: IETF meetings participation (Atlanta and Orlando) Administrative support and guidance for submission of "Compression of IPsec AH and ESP headers for constrained Environments" IETF draft. Preparation of IoT PhD Summer School: Routing protocols for IoT, Industry panel

		10,122.50 10,112.50	Deliverable 2.23 : Market analysis and exploitation plan **WP3 -> 0.5 MM** Calipso architecture: use cases, requirements and specifications: IPSO Alliance Deliverable 3.322 : Integrated architecture with proposed mechanisms **WP4 -> 0.5 MM** Bringing IP connectivity into Smart Objects: Experience from large scale RPL deployment section of deliverable 4.41
	Subcontracting	0	
	Travel costs	0	
	Equipment	0	
	Remaining costs	0	
TOTAL DIRECT COSTS AS CLAIMED ON FORM C		40,450	

6 Financial statements – Form C and Summary financial report

Please find on next pages a copy of Forms C for each partner and the Summary Financial Report.

7 Certificates

This section presents the list of Certificates, which are due for this period, in accordance with Article II.4.4 of the Grant Agreement:

Beneficiary	**Organisation short name**	**Certificate on the financial statements provided? yes / no**	**Any useful comment, in particular if a certificate is not provided**
1	TCS	NO	Expenditure threshold not reached
2	CNRS	NO	Expenditure threshold not reached
3	SICS	NO	Expenditure threshold not reached
4	UPA	NO	Expenditure threshold not reached
5	DRZ	NO	Expenditure threshold not reached
6	WOS	NO	Expenditure threshold not reached
7	CISCO	NO	Expenditure threshold not reached