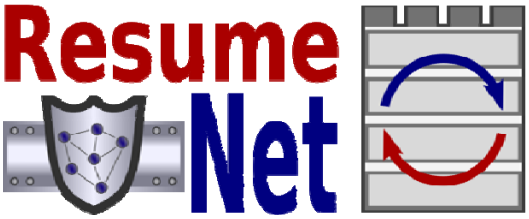
Resilience and Survivability for future networking: framework, mechanisms, and experimental evaluation



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Publishable summary

The work in the context of the ResumeNet project proposes a systematic architectural approach to Internet resilience that attempts to maximize interoperability with legacy network components.

In ResumeNet we understand **resilience as the ability of the network to provide and maintain an acceptable level of service in the face of various faults and challenges to its normal operation.** The term "service" includes the ability for users and applications to access information when needed (e.g., Web browsing and sensor monitoring), the maintenance of end-to-end communication association (e.g., tele- and video conferences), and the operation of distributed processing and networked storage. Our definition of resilience is therefore a superset of commonly used definitions for survivability, dependability, fault tolerance, and performability. The challenges that may impact normal operation include unintentional hardware/software misconfigurations, large-scale natural disasters (e.g., hurricanes, earthquakes, ice storms, tsunami, floods), malicious attacks from intelligent adversaries against the network hardware, software, or protocol infrastructure including DDoS (distributed denial of service) attacks, challenges related to the communication environment such as mobility, error-prone radio channels, and high latency, unusual but legitimate traffic load such as a flash crowds.

Our approach to understanding and implementing resilience in future networks evolves gradually within the project lifetime from the more abstract aspects of strategy and framework towards the more practical implementation issues.

At the highest level of abstraction the requirements from resilient networks are summarized in the six-step *strategy* D^2R^2+DR (Defend, Detect, Remediate, Recover, Diagnose and Refine). These straightforward Ds and Rs effectively order the required resilience functionality with respect to the nature of the different actions, i.e., proactive (preventive) vs. reactive, but also, more importantly, their timing: Detect, Remediate and Recover outline the shorter-term control loop in resilient networks' operation, whereas Diagnose and Refine compose the outer, longer-term control loop. The six strategy components could be easier conceptualized with the help of the castle metaphor.

- *Defence*, according to which the Internet is made robust to challenges and attacks (analogy: strong castle wall);
- *Detection* of an adverse event or challenge that has impaired normal operation of the Internet and degraded services (analogy: guards on the castle wall);
- *Remediation* in which action is autonomously taken to continue operations as much as possible and to mitigate the damage (analogy: boiling oil and fortification of internal walls when the castle wall is breached by a trebuchet);
- *Recovery* to original normal operations once the adverse event has ended or the attacker has been repelled (analogy: cleaning up the oil and repairing the hole in the castle wall);
- *Diagnosis* of the root cause of the challenge that impaired normal operation. This could be used to improve the system design and ease the recovery to a better state (analogy: determine the way in which enemy soldiers entered the inner walls of the castle); and
- *Refinement* of future behaviour based on reflections of the previous cycle (analogy: construction of a thicker wall that will defend against current and predicted trebuchet technology).

For a network to be able to carry out these six operations, we need a good understanding of several concepts. This work is undertaken within ResumeNet in the context of WP1 (framework) and involves a) understanding and characterizing challenges to the normal network operation and their impact; b) exploring proper metrics for measuring and assessing the network resilience; c) defining policies that can outline but also border the remediation space of the network; d)

determining ways to collect and share information from different layers for enabling the detection and remediation actions.

The work on framework then inputs to the studies of mechanisms in WP2 and WP3. First, we explore and develop a set of architectural principles on which resilient systems in general, and the Internet in particular, should be based. Examples of such principles are self-protection, redundancy, diversity, with their corresponding resource tradeoffs. We consider how these could be realized at different network levels and functions, e.g., at topology level, in routing, or as part of transport protocols; but also at the application level via use of peer-to-peer and overlay implementations or virtualization.

Research effort is also put on particular processes that can be viewed as the building blocks of resilient networking such as monitoring, learning processes, and decision engines. It is, in fact, the synthesis of these blocks that will enforce resilience to the various network layers. One of the questions pursued in the project is to what extent could their systematic definitions ease their reuse and result in scalable solutions.

The evaluation of both principles and mechanisms is carried out via analysis and experimentation. Four case studies have been defined to exemplify the application of the framework in concrete service provision scenarios. They represent a well-balanced mix of networking paradigms with both short-term and longer-term potential for commercial exploitation. Experiments are carried out on testbeds; some of them are in-house experimentation facilities, deployed or enhanced for the needs of the project (e.g., ETH Zurich TikNet, Uppsala Haggle testbed), whereas others are larger-scale facilities made available to the research community via dedicated projects (e.g., Planetlab and its European analog, Planetlab Europe).

ResumeNet aims at having a broader socio-economic impact by contributing, though not to the same extent, to the following four points, as quoted from the FP7 ICT Work program for 2007-08 for the strategic objective ICT-2007.1.6:

- Strengthened European position in the development of the Future Internet.
- Wider take-up of technological developments in networks and service infrastructure facilitated by a comprehensive validation of the technological and service choices.
- Global consensus towards standards and strengthened international cooperation through interconnected test beds and interconnection capabilities offered to third countries.
- Higher confidence in the secure use of the Internet through test beds enabling trusted access to e-Services.

The emphasis over the first year of the project has been on the development of the framework for embedding resilience in the future networks. This work is largely carried out within the WP1. The project work has mainly addressed the characterization of challenges to the network operation and their impact, and the development of metrics for assessing the resilience of network and services. In parallel the first studies of policies and platforms for information sensing and sharing among protocol layers have been undertaken.

We have developed a risk management based approach for assessing and classifying challenges to network operation. As starting point, our approach considers the critical assets associated with a system. Via step-by-step system analysis and identification of challenge scenarios, the approach builds an *exposure graph* that quantifies the risks related to the different challenges. The rationale is that the monetary and computational resources available for resilience are expected to be finite. Therefore, we need to understand the *high impact* challenges a networked system will face, so that defensive and remediation measures should primarily address those challenges.

On the metrics' side, Technical University Delft and Kansas University work on a multilevel framework that can assess the network resilience, as viewed by different layers of the protocol

stack. Starting from the physical topology resilience, analysis and simulation are combined to get a view of how higher layers may attenuate or accentuate the impact of challenges on network performance, as this is experienced from different network functions and assessed from different viewpoints (e.g., user vs. network operator).

Tasks 1.4 (on policies for resilience) and Task 1.5 (on cross-layering and multi-level approaches for resilience) were launched in M6 of the project. Policies are viewed as enablers but also constraints, in the same time, of the remediation space. Whereas, cross-layer control and information sharing are crucial for the short-term control loop of the D^2R^2+DR strategy, involving challenge detection and remediation. In both cases, important inputs are expected from the INTERSECTION[1] and ANA[2] projects, both EU R&D projects in the area of future networks.

In WP2, officially launched in M9, the main progress has been made in the area defensive measures. The relevant research activities started well before M9 and the first deliverable reporting on them is due in M15. Four activities are currently undertaken by the partners of this task. "*Exact and approximation approaches for the design of survivable and robust networks*" looks at optimization problems from a graph theoretical point of view design resilient networks. The work on "*Protection against malicious information spread*" analyses how well nodes need to be protected to withstand worms and viruses in a network. Research on "*End-to-end transport and mechanism diversity"* focuses on novel approaches for multi-path routing in large-scale networks. Finally, investigations on "*Integrating 'Quality of Service' with 'Quality of Security' "* have led to the development of a framework which balances performance and security during challenging conditions.

Regarding WP3, launched in parallel with WP2, initial work has focused on the use of P2P and overlay networks for resilient service provision. Overlay networks and system virtualisation techniques were analyzed and a set of guidelines were derived for using them in providing resilience services. Furthermore, the use of a cooperative approaches (involving a centralized server component and the P2P paradigm) for session setup (in particular, session setup of VoIP sessions using the SIP signalling), was analysed in terms of reliability and security. A draft solution for service lookup using P2P networks has been sketched, which is currently compared to DNS.

Finally in WP4, significant effort has been devoted so far to the more detailed specification of the experimentation scenarios and the respective testbed development work, where appropriate. This work is directly influenced by the progress made on the framework (WP1) and mechanism (WP2-WP3) aspects of the project. Although WP4 work officially starts in M18, both test beds (in the case of TikNet) and experimentation scenarios (study cases 1-2, 4) have been defined in higher detail, whereas for experimentation study case 2, preliminary experiments have already begun. In parallel, the activities in WP4 support the activities of the EU FIREWorks Coordination Action[3] via compilation of two light deliverables on the experimentation facilities and the links between research and experimentation in ResumeNet.

Despite its short history, ResumeNet has devoted considerable effort to the dissemination of its results:

- The project Web site and Wiki pages, initially due for M2, are operational since November 2008 (http://www.resumenet.eu/). The public website pages have seen one major update during August, which involved both information and presentation aspects.

[1] http://www.intersection-project.eu

[2] http://www.ana-project.org

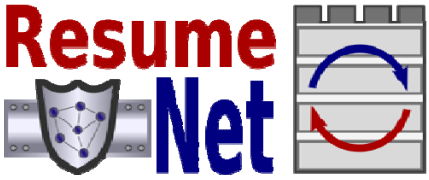
[3] http://www.ict-fireworks.eu/

- ResumeNet has been presented, with the use of flyers, posters[4], or slide sets, in various venues including magazines (ERCIM journal); scientific conferences and workshops (IWQoS 2008 Conference, IWSOS 2008 Workshop); events organized by the European Commission (SAC/FIRE Workshops, FIRE Launch Event, ICT 2008). In the same time, significant work carried out within the project or during the project bidding and preparation phases has been published in conferences and scientific journals. Last, but not least, local media have hosted interviews of ResumeNet Consortium members on the relevance of ResumeNet work to the future Internet.
- ResumeNet has been closely monitoring the activities of the Future Internet Assembly, supporting the coordination activities of FIREWorks, and participating in the meetings of the FIRE Expert Group. It is always keen to support standardization actions originating from these bodies and federating the European industry sector. Nevertheless, the project has also invested resources on *direct* standardization actions. Such is the case with the ITU-T Focus Group on "Future Networks", established in January 2009 by Study Group 13 ("Future networks including mobile and NGN").
- A Dagstuhl Seminar on "Architecture and Design of the Future Internet" was organized by Georg Carle, David Hutchison, Bernhard Plattner, and James P.G. Sterbenz, all partners of the ResumeNet project, on 14-17 April 2009. Prominent researchers and practitioners with interests in the area of networking were invited to exchange views on trends and proposals about the future of communication networks. Network resilience and the ResumeNet approach to it attracted significant share of the overall discussion over the three days of presentations and forum-like interactions,
- Exchanges have also taken place with EU projects carrying out activities on network resilience. Contacts have been made to the FP6 Network of Excellence ReSIST (http://www.resist-noe.org/) to ensure that ResumeNet actors and results will be included in the Resilience Knowledge Base, one of the main deliverables of ReSIST. Chidung Lac (FT), the leader of ResumeNet WP5, is part of the Advisory Board of the FP7 Coordination Action AMBER (http://amber.dei.uc.pt/), which focuses on resilience measuring, assessment and benchmarking. Similar interactions have been possible with the FP6 Integrated Projects ANA (Autonomic Network Architecture) and Haggle, as well as with the FP7 project ECODE, thanks to common partners in those Consortia. With ANA, in particular, a joint workshop was held on June 12th in Lancaster, UK, before the 2nd plenary meeting of the project. The aim was to identify what ANA outcomes could be reused and can benefit the work in ResumeNet.

Further evidence to the impact ResumeNet has had so far comes from companies and institutions that approached the project and expressed their intention to initiate their own research activities on the topic of network resilience (Australian Defence Science and Technology Organisation, National University of Defense Technology (NUDT) of China) or link existing ones to the ResumeNet work (OFCOM and QinetiQ in UK).

Finally, considerable effort over this first year of the project has been devoted to the set-up of adequate management tools and processes. “Well begun is half done”; therefore, the concern of the management team has been to put in place all those tools and processes that can ensure a smooth collaboration amongst partners but also their commitment to the project research plan. In this direction, the management has, on the one hand, applied best practices and, on the other hand, experimented with tools and processes that appear to ease and foster collaboration within the project.

[4] A second, and detailed, version of ResumeNet's poster is available now in the public Web site.



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1. Project objectives for the period

The main objectives during the first year of the project lifetime were related to both research and management.

Research-related: the objective for the first year has been to develop as much as possible the different components of the resilience framework. Challenges and their impact assessment, metrics, policies, and platforms for sensing and sharing information from different layers, including the monitoring function, are the main components of the proposed framework. Each one poses its own requirements to the network and service architecture and has to be eventually realized in the network infrastructure and/or applications. The overall progress on the framework aspects is captured in deliverable D1.5a, whereas the latest on the particular question of challenge characterization and impact assessment is the subject of deliverable D1.1.

Work in WP2 and WP3 started later in the project lifetime, in the beginning of M9. The main aim there has been to detail further the work plan, determine more precisely the inputs/outputs among tasks and accommodate the progress of research work on the framework aspects. Priority in these first four months has been given on the study of defensive measures, i.e., the first D of the D^2R^2+DR strategy.

Work on experimentation officially starts in M18. Nevertheless, it was realized from the beginning that the definition of the four study cases would need to adapt to the new inputs from WP1 and, in the course of time, from those in WP2 and WP3. The aim has been to update their specification so that they can evaluate the maximum possible number of concepts and mechanisms, as studied in WP1-WP3.

With respect to WP5, the objective for the first year was to make the ResumeNet project visible to the research community. The website development and maintenance, presentation of research work towards academic and scientific venues, active involvement and organization of events were identified as means to leverage the visibility and impact of the project. Moreover, establishing clear links to other relevant research activities both in Europe and worldwide was seen as one of the key targets for the first year of the project.

Management-related: The basic concern of the management team for the first year was to put in place and enforce the use of all those tools and processes that can ensure a smooth collaboration amongst partners but also their commitment to the project research plan. On the technical management side, one of the aims set was the formation of a group of experts, who would take on the role of Advisory Board for the project. These experts could help the steering of the project towards well defined research objectives with added value for the research community but also the network practitioners.

In the following sections, we summarize the steps made in both directions during the reporting period.

2. Work progress and achievements during the period

2.1. WP1: Framework for resilience and networking

2.1.1. Per-task summary of progress towards objectives

For a detailed description of progress in Work Package 1 (WP1) the reader is referred to the ResumeNet deliverable D1.5a – *First Interim strategy document for resilient networking*. Here a summary of progress for each task is given.

Task 1.1: Strategy for resilient networking

The objective of this task is to lay down the overall approach to the resilience question in the project, consolidate the results obtained from the different project tasks and inform research activities. Via D1.5a, this task has described our current understanding of how the resilience strategy adopted by the project – D^2R^2+DR – could be practically realized and evaluated. In particular, we understand the need for different forms of challenge detection to be able to remedy challenges appropriately and the potential need for remediation to be enacted on different timescales. Identified was the need to understand the relationship between building defensive measures and the extent to which a distributed monitoring and challenge assessment platform is required.

The slight restructuring of research work in WP2 and WP3 (ref. sections 2 and 3 of this document) and the update of WP4 experimentation scenarios in response to the progress of research work in WP1, were also outcomes of this task.

Task 1.2: Understanding challenges

In this task, the objective was to gain an insight into the challenges the project should try to mitigate. We quickly realized the importance of understanding *risk* in relation to challenges and how determining measures of risk should significantly influence how a network is engineered to be resilient. In essence, the monetary and computational resources available for resilience will be finite, therefore we need to understand the *high-impact* challenges a networked system will face, so that defensive and remediation measures can be built to primarily tackle these challenges.

In light of this, we developed a risk assessment approach, the first version of which is described in D1.1. As starting point, our approach considers the critical assets associated with a system. Via analysis of the system and challenges that relate to the specific system context, a measure of exposure is determined for a given challenge scenario. To aid this assessment approach and support comprehensiveness, we developed a classification of challenges.

D1.1, which describes our risk assessment approach and the challenge classification, was delivered before M7 of the project. At that time, we felt there was much we still needed to investigate in relation to the risk assessment approach (Task 1.2 ran for 6 months); therefore, we proposed to issue a revised version of the deliverable later in the project lifetime.

Task 1.3: Resilience metrics

In our effort to develop metrics for resilience, we have taken two complementary approaches. One approach, adopted by TU Delft, takes an analytical approach to determining resilience metrics, aiming at the derivation of *hard* bounds on the performance of a network topology in various challenge scenarios. For example, given a network topology, the aim is to give absolute best, average, and worst case measures (given metrics, such as path length) of resilience given various forms of challenge, which are modelled as link cuts. Highlighted is the need to understand the envelope between the best and worst case scenarios, which a network provider may wish to minimize. To date, topology metrics have been considered; higher-level, more service-centric, metrics and the relationship they have with topology, will be investigated in future work.

The second, complementary approach, being adopted by Kansas and Lancaster Universities, is developing a multi-level framework for resilience quantification. The fundamental concept in this approach is to quantify resilience as a measure of service degradation in the presence of challenges (perturbations) to the operational state of the network. For a given layer boundary, the approach divides the operational and service space into three regions, based on a number of scenario-specific factors. These are termed as normal, partially degraded, and severely degraded for the operational space and acceptable, impaired, and unacceptable for the service space. The initial studies that were conducted used simulated topologies, where the topologies can be constrained by certain geographical constraints, e.g., to POPs.

Using a set of common topologies, from the GEANT and Sprint networks, experiments have been conducted to understand the complementariness of the two approaches to measuring network resilience – the initial results are summarized in D1.5a, whereas the first detailed report on the work on metrics is due in M18.

Task 1.4 Policy specification for resilience

In this task, we aim to understand the role of policies for building resilient networked systems. In this first year, we have developed an understanding of the state-of-the-art, investigating such policy management frameworks as Ponder and DEN-ng. We have investigated the use of policies in other related projects, such as the EU FP7-funded INTERSECTION project [INTER], where they are being used to direct the mitigation of attacks. For the moment, we envisage policies being used to guide appropriate remediation, in a similar fashion to the INTERSECTION project; only we consider a much broader range of challenges, which may not be positively identified, and use policies to describe the various contexts in which resources can be applied for resilience inline with organizational or individual requirements. Our continuing work in this area will further investigate the use of policies in a small number of well-defined challenge scenarios.

Task 1.5: Cross-layer optimization and multi-level resilience

In this task, we aim to understand the various trade-offs associated with cross-layer control and information sharing. As a starting point, we undertook a comprehensive literature survey to understand the current state-of-the-art – the highlights of which were published in a student workshop. Our work now has begun to focus on developing formalisms for cross-layer information sharing and control, with two aims: 1) to determine the trade-offs associated with the various forms of cross-layer approaches, in relation to service requirements; 2) to allow resilience engineers to reason about when cross-layer control loops could lead to system instabilities. As a starting point for this work, we are developing a notation to describe the various forms of cross-layer information sharing and control, and considering the simple scenario of error control, and the approaches to this (e.g., end-to-end vs. hop-by-hop and mechanisms, such as FEC and ARQ).

In this task, we have also been investigating approaches to distributed monitoring that the project could leverage. Two promising approaches, because of their technical merit, access to their code-base, and close relationships with the project, are the IS Framework, developed in the EU FP6-funded ANA project [ANA]. and the ANA monitoring architecture. We have conducted initial experiments with the IS framework to determine its suitability and when the code-base for the ANA monitoring architecture becomes available, we will also carry out experiments with it.

The following summarize the main results from WP1 during the first year:

- The development of a novel risk assessment approach to determine the high impact challenges associated with a networked system;
- A classification of challenges that are to be addressed by the project;

- The development of understanding of the state-of-the-art in cross-layer approaches, resulting in a publication in a student workshop;
- Development of approaches to resilience metrics, with an understanding of how the approaches adopted relate; this is achieved via some initial experimental results;
- Understanding of the state-of-the-art in policy management frameworks that can be built upon when further understanding the role of policies for resilience.

2.1.2. Deviation in the time plan and the WP structure from the technical annex

There have been no significant deviations from the time plan, as described in the technical annex, with the exception of one minor point: both NEC and ULANC have extended their effort on Task 1.2 over a longer period than initially described in the technical annex to accommodate the development of a revised version of D1.1.

2.2. WP2 Network-level resilience

Work Package 2 (WP2) had his internal kick-off meeting at March 18th in Heidelberg. There, the task leaders together with the work package leaders of the other technical work packages discussed the work items defined in the description of work. Two modifications resulted from these discussions: 1) Replace the work item on "Distributed Anomaly Detection" with the new work item on "Distributed Store for Challenges and Remediations"; 2) The results of work item "Resilience of large scale communication networks" will go into deliverables D2.3a and D2.3b instead of D2.2a and D2.2b. The justifications for these amendments are detailed below.

The technical work of WP2 started in M9 for tasks 2.1 and 2.2 whereas task 2.3 is starting in M12 only. The current status of the various work items currently executed by WP2 partners can be found in D6.3. Here, a brief summary of tasks 2.1 and 2.2 focusing on the management aspects is presented.

2.2.1. Per-task progress towards objectives

Task 2.1. Defensive measures

Task 2.1 is investigating defensive measures, which are pro-active mechanisms preventing challenges from affecting a networked system. Four activities are currently undertaken by the partners of this task. "*Exact and approximation approaches for the design of survivable and robust networks*" looks at optimization problems from a graph theoretical point of view design resilient networks. The work on "*Protection against malicious information spread*" analyses how well nodes need to be protected to withstand worms and viruses in a network. Research on "*End-to-end transport and mechanism diversity"* focuses on novel approaches for multi-path routing in large-scale networks. Finally, investigations on "*Integrating 'Quality of Service' with 'Quality of Security' "* have led to the development of a framework which balances performance and security during challenging conditions. These four activities have shown good progress and will report their results in D2.1a "*First draft on defensive measures for resilient networks*" which is due in M15.

Task 2.2. Challenge detection

D2.2a "First draft on new challenge detection approaches" will be available in M18. This deliverable will contain the ongoing research work on "Understanding normal behaviour", "*E2E challenge detection*" and "*Distributed Store for Challenges and Remediations*". The scope of E2E challenge detection has been defined to include event correlation and root cause analysis. The ongoing work has defined an architecture for distributed light-weight challenge detection framework. Moreover, event correlation engines and root cause analysis tools are evaluated to be included in this component. The results of this analysis will be made available to the remediation

framework but is also stored persistently in a distributed storage. This storage will also contain information about applied remediation strategies and their success assessment developed in task 2.3. This gathered information is envisioned to be used by machine learning algorithms for system evolution in task 2.3 in the last phase of this task.

The short duration WP2 has been running officially would not allow for significant results. But research work executed by various partners just recently provides a solid basis for research with tangible results. This work has been documented in D5.2a providing additional information about the relationship of the respective research work to ResumeNet. Publications on *defensive measures* from the work items on *node protection* and *E2E transport and mechanism diversity* have been accepted in journals and conferences. The proposed work will be picked up in ResumeNet and be carried on further significantly. A publication on *E2E challenge detection* is currently in preparation.

2.2.2. Deviation in the WP structure from the technical annex

Redefinition of subtask T2.2.2.

The Subtask T2.2.2 on "Distributed Intrusion Detection" has been removed from the work items of ResumeNet as work on this research topic has also been proposed from Lancaster University as their contribution to the EU FP7 Call 2 project ECODE. Instead of duplicating this work, ResumeNet will reuse the findings from ECODE as they are made available. Lancaster University executing this work in ECODE will be monitoring the progress on behalf of ResumeNet. The resource assigned to this subtask will be used for the newly introduced work item on "Distributed Store for Challenges and Remediation". The subtask description for T2.2.2 has been changed to reflect this change:

> ***T2.2.2 Distributed store for challenges and remediation***
>
> There is a need to have generic ways to interface different functional blocks, e.g., a challenge detection block (such as anomaly detection) and a block that is supposed to mitigate the effect of the challenge. The goal for such a distributed store is two-fold. First, it will process notifications of (pre-)challenge events to provide context to detection and remediation blocks. Second, it will provide a history of challenges, annotated with meaningful events and remediation actions. Such histories can further assess the performance of remediation techniques and be used as a database for learning the appropriate remediation of future challenges (i.e., input to T2.3).
>
> It is expected that such communication could be implemented by a storage compartment together with a publish-subscribe interface. Detection blocks would publish challenges in this compartment and other functional blocks could subscribe to some challenges matching their input filter to enable their control loop. Though, alternative approaches such as events log or "challenge record" database will be investigated as well. We will study suitable approaches regarding scalability and flexibility of publishing scopes. The solution will also have to operate with limited traffic overhead.

Redirecting output of subtask T2.2.3 on "Resilience of large scale communication networks"

The work on "Resilience of large scale communication networks" focuses on changes to security and access control policies in face of various challenges. Detection of these challenges is a necessary prerequisite but can utilize results from other work items within task 2.2 on challenge detection as well as from the Work Package 3 task on "Service surveillance and detection of challenging situations". Therefore, the focus of subtask 2.2.3 is shifted towards investigating how a framework for dynamic policy management of security and access control policies should be designed. Such a framework is clearly an implementation of a remediation strategy reconfiguring the system according to the detected challenge. It complements the activities on remediation

strategies developed in task 2.3. Therefore, the contribution coming from T2.2.3 will be reported within D2.3a and D2.3b, respectively, which present the findings on remediation and recovery strategies.

2.3. WP3: Service-level resilience

WP3 started officially in M9, i.e., in May 1st 2009. However, TUM, which is WP leader, has started activities in WP3 pretty early in the project. The activities of TUM include:

- coordination with other WPs which is part of Task 3.1.1 ('Architecture for resilience-aware services, interaction with allocation options (P2P, Virtualisation)')
- more focused research activities in the area of P2P-based resilient services (Task 3.2)

Activities in Task 3.1.1 were necessary at an early stage, in particular since WP1 has started at M1, and coordination between the two WPs has been necessary and fruitful. Activities in Task 3.2 have been conducted focussing on P2P-related research but still interacting with other WPs, in particular WP1 and WP4. The TUM team had the sufficient capacity to put more effort on this from the beginning in order to avoid peaks and bottlenecks in the effort required to meet the project goal in the next 2 years.

2.3.1. Deviation in the time plan and the WP structure from the technical annex

Between M1 and M8, activities between WP3 partners had mainly to do with coordination and exchange of knowledge and ideas. The official start of work happened in M9. The discussions led to a slight change in the structure of the WP.

Table 2.1: WP3 structure as in the technical annex

T3.1	***Resilient services framework (TUM, UP)***
3.1.1	Architecture for resilience-aware services, interaction with allocation options (P2P, virtualization) (TUM)
3.1.2	Comparison of P2P, overlays and virtualization technologies (UP)

T3.2	***Secure application of P2P and overlay networks for resilient service provision (NEC, TUM)***
3.2.1	Dynamic service allocation based on P2P-mechanisms (TUM)
3.2.2	Resilient transport using overlay networks (NEC)
3.2.3	Security of P2P-based services (TUM)

T3.3	***Management and security of virtualization services (UP)***
3.3.1	Management of virtual services; finding services after movement (UP)
3.3.2	Security of virtual services (UP)

T3.4	***Service surveillance and detection of challenging situations (FT)***

T3.5	***Control algorithms (TUM, UP)***
3.5.1	Decisions engines to manage services, e.g., move / copy / delete services (UP)
3.5.2	Feedback control loops and learning methods (TUM)

Table 2.1 shows the WP structure as in the technical annex. Table 2.2 shows the new structure (sub-tasks that were omitted are crossed out, while new (sub)-tasks are in italic).

- Task 3.1 remains unmodified

- Task 3.2 contains a new sub-task 3.2.2 “Quantification of the resilience of P2P overlays”.
- The previous Task 3.2.2 (“Resilient transport using overlay networks”) carried by NEC is now moved to the new Task 3.5 (“Overlay-based connectivity”). NEC is focussing on using overlays for exchanging network management and resilience information there (new sub-task 3.5.1), while TUM is investigating data forwarding including routing research questions (sub-task 3.5.2).

Table 2.2: WP3 new structure

T3.1	**Resilient services framework (TUM, UP)**
3.1.1	Architecture for resilience-aware services, interaction with allocation options (P2P, virtualization) (TUM)
3.1.2	Comparison of P2P, overlays and virtualization technologies (UP)

T3.2	**Secure application of P2P and overlay networks for resilient service provision (NEC, TUM)**
3.2.1	Dynamic service allocation based on P2P-mechanisms (TUM)
~~*3.2.2*~~	~~Resilient transport using overlay networks (NEC)~~
3.2.2	*Quantification of the resilience of P2P overlays (TUM)*
3.2.3	Security of P2P-based services (TUM)

T3.3	**Management and security of virtualization services (UP)**
3.3.1	Management of virtual services; finding services after movement (UP)
3.3.2	Security of virtual services (UP)
3.3.3	*Decisions engines to manage services, e.g., move / copy / delete services (UP)*

T3.4	**Service surveillance and detection of challenging situations (FT)**

~~***T3.5***~~	~~**Control algorithms (TUM, UP)**~~
~~3.5.1~~	~~Decisions engines to manage services, e.g., move / copy / delete services (UP)~~
~~3.5.2~~	~~Feedback control loops and learning methods (TUM)~~

T3.5	***Overlay-based connectivity (TUM, NEC)***
3.5.1	*Using overlays for exchanging resilience information (NEC)*
3.5.2	*Using overlays for data forwarding (TUM)*

- The previous Task 3.5.1 (“Decisions engines to manage services, e.g., move / copy / delete services”) carried by UP has been moved to Task 3.3 (“Management and security of virtualization services”).
- Finally, the previous task 3.5.1 (“Feedback control loops and learning methods”) was abandoned by TUM to the advantage of research on “Overlay-based connectivity”. TUM has now a subtask 3.5.2 “Using overlays for data forwarding”. Activities related to “learning” (outer control loop in the D2R2+DR strategy), which were planned in the previous Task 3.5.1 have been abandoned (although some results from WP2 in this direction could prove to be useful in the future).

To summarise, the modification of the WP3 structure has been useful in order to focus more on the following research topics:

- P2P networks for resilient services
- Virtualisation for resilient services
- Service surveillance and detection of challenging situations

- Overlay-based connectivity

The new structure matches these topics (Task 3.2, 3.3, 3.4 and 3.5). The effort in terms of MM has been slightly re-shuffled in order to fit this new structure, but the overall effort per partner remains the same.

2.3.2. Per-task summary of progress towards objectives

Task 3.1 Resilient services framework

As mentioned above, Task 3.1.1 is an on-going activity for the coordination with other WPs. In particular, discussions with WP1 in the topics of understanding challenges, metrics and policies took place and are still on-going.

Task 3.1.2 provided a comparative study of overlay networks and system virtualisation techniques and guidance for using them for providing resilience services. This is documented in D3.1.

Task 3.2 Secure application of P2P and overlay networks for resilient service provision

In Task 3.2, the use of a cooperative approach (server and P2P) for session setup, in particular session setup of VoIP sessions using the SIP signalling, was analysed in terms of reliability and security. A draft solution for service lookup using P2P networks has been sketched, which is currently compared to DNS. More details can be found in D6.3.

Task 3.3 Management and security of virtualization services

Task 3.3 starts officially at M16 (Dec. 2009). Therefore, the work on this task has been restricted to some high level investigations on how to find services hosted by virtual machines after they have been migrated and how to use SCTP for resilient services. More details can be found in Deliverable D6.3.

Task 3.4 Service surveillance and detection of challenging situations

Task 3.4 on “Service surveillance and detection of challenging situations” started on M9. A state-of-the-art analysis has been provided on service monitoring and event correlation for challenge detection, which is documented in D6.3.

Task 3.5 Overlay-based connectivity

In Task 3.5 the problem statement has been defined and research issues have been identified. These are documented in D6.3.

In summary, T3.3, T3.4, and T3.5 have either not started yet or started in M9 (May 1st 2009). Therefore, they are premature to produce significant results. D3.1 is a result of T3.1. Task 3.2 has not produced visible results in terms of deliverables or publications but has provided a deep insight into reliability, security and signalling algorithms in P2P networks with respect to their deployment for resilient services, which provides a basis for the upcoming results. Please refer to Deliverable D6.3 [ResD6.3] for details.

2.4. WP4: Experimental evaluation of resilient networking

In the experimentation part of the project, the aim is to exemplify our approach to resilience in concrete study cases. Work Package 4 (WP4) has been structured around study cases, which are effectively combination of {networking technology, service provision scenario, challenge set} tuples. Each one assesses a subset of the D^2R^2+DR strategy aspects and the concepts/mechanisms realizing it.

Although work on experimentation begins in the second half of the project lifetime, significant effort has been devoted so far to the more detailed specification of the experimentation scenarios

and the respective testbed development work, where appropriate. This work is directly influenced by the progress made on the framework (WP1) and mechanism (WP2-WP3) aspects of the project.

2.4.1. Per-task summary of progress towards objectives

Task 4.1. Resilient routing and medium sharing in Wireless Mesh Networks

Monitoring and management software has been developed for the Wireless Mesh Network testbed [TikNet], which is deployed at the G floor of the Department of Electrical Engineering and Information Technology, in ETH Zurich. In addition to this, the basic software and hardware of the testbed have been upgraded to more recent versions.

The experimentation scenario has seen a couple of iterations, triggered by the elements of work in WP1, and particular task 1.2 on the assessment of challenges' impact. The current thinking is to carry out experiments assessing the impact of resilience on throughput and delay of the WMN by using the Click software modules. Preliminary work has also begun with simulations that will support the real experimentation.

Task 4.2. Resilient forwarding in opportunistic networks

The testbed to be used for these experiments is being developed in the context of the EU FP6 Haggle project. Additional work in ResumeNet will concern the development of modules related to the implementation of node misbehaviours. The work so far has addressed the definition of the service scenario. The current thinking is to use as reference the push-based system developed in Haggle for data delivery. Some first selfishness and attack scenarios have been identified and initial experimentation with the ONE simulator has begun.

Task 4.3. Service-level resilience evaluation

TUM has been conducting its testbed activities in WP4 inline with the work in WP3. The implementation of cooperative SIP signalling between DHTs and servers (CoSIP) was ported from the Bamboo DHT implementation[5], which is in Java to a Kademlia implementation in Python called Entangled[6], not only because the CoSIP engine was implemented in Python, but also because Kademlia has interesting properties from resilience point of view. Furthermore, tools have been developed to setup a highly distributed CoSIP testbed with 400-500 peers on PlanetLab (currently only one CoSIP peer per PlanetLab node is possible). The peers emulate phone calls regularly. The CoSIP implementation was enhanced by diagnostic tools. Diagnostic data are sent regularly to a server at TUM for further evaluation. Currently, a web site is under construction at www.cosip.org where a life demo is currently developed.

UP has been investigating different options for running experiments with resilient services running in virtual machines. PlanetLab is not designed to be used for the testing of virtualized environments. Experimentations trying to avoid this limitation have been realized by using emulation platforms (e.g., Qemu). The results showed that this method is not flexible enough. Therefore PlanetLab is not considered for further resilient services experiments with virtualisation. G-Lab and GpENI are further testbed platforms where UP is considering using them to run service level resilience experiments. Preliminary considerations regarding their relevance to the ResumeNet project is currently work-in-progress. The G-Lab project (started 1. Sept. 2008) has the main objective of enabling autonomous energy efficient management of physical and virtual resources. UP is joining the testbed on Sep. 1st 2009. The first phase will be to set-up 6 nodes of the testbed, out of which three are standard G-Lab nodes and the other three are latest generation Sun nodes supporting energy efficiency features. G-Lab should us allow to manage the services underlying virtualization software with the functionality that is required for the experiments with service resilience in ResumeNet.

[5] http://bamboo-dht.org/
[6] http://entangled.sourceforge.net/

Task 4.4. Resilient smart environments

The testbed to be used is being developed in the context of a French national research activity. The work in ResumeNet has not yet started.

Task 4.5. Cooperating towards a possible federation of testbeds in the FIRE context

This is the only WP4 task that has been officially kicked off. It is responsible for feeding information to the FIREworks coordination action. In the context of this task, the experimentation scenarios, the facilities envisaged in the project, and implications with respect to federation have been described in the deliverable D4.1a submitted to the EC (ref. Table 3.1). Note that this deliverable reflected the understanding within the project by M6 and will be revised in M18.

2.4.2. Deviation in the time plan and the WP structure from the technical annex

With respect to the work plan in the description of work, there are no modifications. The only deviation has to do with the distribution of WP4 effort across time; in several cases, partners have already initiated their efforts related to preparing/enhancing testbeds and experimentation scenarios instead of postponing the launch of effort for M18.

2.5. WP5: Dissemination and exploitation of project results and standardization activities

2.5.1. Summary of progress towards objectives

Web site and Wiki

The first efforts of ResumeNet have been devoted to the creation of the Web site. The site (http://www.resumenet.eu) became operational less than two months after the official start of the project, i.e., in mid-October 2008. A major revision of its pages has been realized recently, i.e., in July 2009. Besides the main page containing basic information (e.g., duration of the project, contract number), the website content has been structured along six components: Project, Consortium, People and Roles, Results, News and Events, Related Activities and Projects.

The Wiki pages for the Consortium's daily work have also become effective in early October 2008. This private area is the zone used by all ResumeNet members to organize administrative, logistical, and technical tasks. In addition to the Wiki, an SVN server is hosted in ETHZ for the collaborative production of all kinds of dissemination material including deliverables, reports, posters, and publications.

Publications

Although the project has only completed the first year of its lifetime, research work out of it has been submitted, and, in some cases, accepted and published, to scientific conferences and journals. Likewise, significant results have been published out of research work carried after the project proposal submission. The number of publications/submissions for 2009 is listed below (see D5.2a for details concerning all WP5 achievements mentioned in this deliverable).

Magazines: 1

Journals: 5

Conferences: 9

Workshops: 4

Ongoing work: 4 (these four papers, covering work done in the project, have been submitted or will be submitted within the next month).

Presentations

Contributing to, and participating in, dissemination events organized by the European Commission is part of ResumeNet commitments. To this end, six presentations on various aspects of the project have been given, mainly in the context of the Future Internet Conference events, organized regularly by the EC and FIRE project clustering activities coordinated by the FIREWorks Coordination Action. ResumeNet has also been presented in the context of 6 scientific workshops and symposiums.

Dagstuhl seminar organization

"Schloss Dagstuhl - Leibniz Centre for Informatics" is the world's premier venue for seminars and workshops in the area of computer science and informatics. Its key instrument for promoting research is the Dagstuhl Seminars, which bring together internationally renowned leading scientists for the purpose of exploring a cutting-edge informatics topic. A 4-day seminar was held in 2009 (14 April – 17 April), covering a broader scope subject: "Perspectives Workshop: *Architecture and design of the future Internet*". The ResumeNet partners who arranged this event are TUM, ULANC, ETHZ, and Kansas University.

This seminar brought together thirty seven experts from Europe, North America, and Asia to discuss the way ahead for the Internet. It was broadly agreed that three aspects are crucial: technological, economic, and societal/political. This was a theme brought out in the opening session and re-visited during the closing discussion. It is finally worth noticing that two ResumeNet presentations have been made during this seminar.

Publicity

In addition to the communication channels described earlier, ResumeNet has exploited other means (e.g., regular newspapers and University magazines) to raise society awareness of its scope and objectives:

On the occasion of the NetArch 2009 Symposium, ResumeNet coordinator (Prof. B. Plattner) has described the project concepts and objectives in the article "Internet 2.0 - Renovation oder Neubau ?" published in "Neue Zürcher Zeitung", one of the oldest and most prestigious Swiss newspapers.

Likewise, "ETH Life", the magazine of ETH Zurich, has recently hosted an interview of Prof. B. Plattner, where ResumeNet is discussed in the context of the broader Future Internet topic.

Finally, it is worth mentioning a considerable collective effort of the consortium allocated in Q2 2009 to update and enhance the initial poster describing ResumeNet strategy and goals, as presented in September 08 and November 08 during the FIREWorks events. This new improved version is available now on the Web site.

Contribution to standardization work

The project Consortium has very good understanding of the challenges related to standardization and outlined very early its standardization strategy; namely, that the impact of ResumeNet on standardization is primarily expected to happen indirectly, potentially via a dedicated Coordinated Action (CA) within FIRE, like the EU FP7 FIREWorks Coordination Action [FIREW]. Nevertheless, the project has also invested resources on direct standardization actions. Such is the case with the ITU-T Focus Group on "Future Networks", established in January 2009 by the Study Group 13 ("Future networks including mobile and NGN").

The Focus Group's objectives are to share the discussion on future networks and ensure global common understanding about these networks with collaboration and harmonization with relevant entities and activities. By collaborating with worldwide future network (FN) communities (e.g., research institutes, forums, academia), this Focus Group aims to:

- collect and identify visions of FN, based on new technologies,

- assess the interactions between FN and new services,
- familiarize ITU-T and standardization communities with emerging attributes of FN,
- encourage collaboration between ITU-T and FN communities.

The inaugural meeting of the Focus Group was held on 29 June - 3 July in Lulea (Sweden), i.e., the same week as the conference "FIRE and Living Labs – Future Internet by the people". ResumeNet, through a talk by Dr. M. Schoeller entitled "Network resilience as a prime feature of future networks", has contributed to this collection and identification of future networks visions, by means of a presentation on resilience terminology and the ResumeNet strategy.

2.5.2. Further impact

During the past 12 months and through personal contacts and Web site visibility, ResumeNet has attracted the interest of various players, in Europe and beyond the European borders, who approached the project Consortium, asking for some form of collaboration. Moreover, links have been established with communities carrying out similar activities elsewhere in the world.

The first of these cases is in the USA, where through the activities of Prof. J. Sterbenz at Kansas University, ResumeNet now has a connection with NSF GENI and other research activities. This is informing our work both in the scientific efforts on resilience (for example metrics) and in testbeds: we are discussing the possibility of using an extension of the GpENI testbed into Europe within the ResumeNet project.

Secondly, the project was approached by Dr. P. Pourbeik of DSTO, the Australian Defence Science and Technology Organisation, who expressed interest in ResumeNet. This led to a visit by Dr. Pourbeik to both ULANC and ETHZ during September 2009. As a result, we have identified several possible strands for exchanging results and, perhaps, collaboration. This will next be followed up by Prof. M. Fry at the University of Sydney, who will investigate the possibility of some joint activity within the context of Australian funding. Prof. Fry has also recently recruited a PhD student to work on ResumeNet. This student has just been awarded a scholarship by NICTA, the Australian national ICT research institute: it has been indicated to NICTA that this may be an entry point to developing a relationship with ResumeNet.

Thirdly, in the UK, the national regulator OFCOM is proposing work on computer network resilience within the context of the Digital Britain report, and ULANC has been approached for possible assistance with this work because of its ResumeNet and related research on resilience. Also, the UK company QinetiQ (similar in many ways to the Australian DSTO) has recently been in contact with ULANC to explore joint work on resilient systems.

Finally, strong interest to the project was expressed by the delegation of the National University of Defense Technology (NUDT) of China during their visit to the ETHZ in summer 2009. The delegation included Prof. Z. Wang (Vice Dean of the Network Engineering Department of NUDT) and Prof. M. Xu (Head of the Network Engineering Department). As a result, the work of a PhD student from NUDT, a guest at the Computer Engineering and Networks Laboratory of ETHZ from November 2008 to November 2009, has been oriented towards the scope of the project, and is viewed as the link between ResumeNet and similar activities to be launched in NUDT.

2.5.3. Deviation in the time plan and the WP structure from the technical annex

No deviation from the work planned in the DoW is to be reported during the first year of ResumeNet WP5 activities.

3. Deliverables and milestones tables

3.1. Deliverables (excluding the periodic report)

Table 3.1. Deliverables

Del. no.	Deliverable name	WP no.	Lead beneficiary	Nature	Dissemination level	Delivery date from Annex I	Delivered	Actual / Forecast delivery date	Comments
1.1	Understanding of challenges and their impact on network resilience	1	NEC	R	PU	M6	✓		Delivered before end of M7 to allow inclusion of risk-assessment approach in the document. A revision of the deliverable is proposed for M12, to accommodate continuing research on challenges.
1.5a	First interim strategy document for resilient networking	1	ULANC	R	PU	M12	✓		
3.1a	Taxonomy of P2P, Overlays and Virtualization techniques with respect to service resilience	3	UP	1	PU	M12	✓		
4.1a	Federation Requirements (Interim)	4	ETHZ	R	PU	M6	✓		Light deliverable in response to the delayed request for inputs from FIREWorks
5.1	ResumeNet website and Wiki pages	5	ETHZ	O	PU	M2	✓		Delivered in time
5.2a	Yearly reports on dissemination	5	FT	R	PU	M12	✓		

	activities								
6.1	Project Management Guidelines	6	ETHZ	R	PP	M2	✓		Delivered in time
6.2a	Links between research and experimentation	6	ULANC	R	PU	M6	✓		Light deliverable in response to the delayed request for inputs from FIREWorks
6.3	Report on technical work in WP2 and WP3 during first year	6	ETHZ	R	PU	M12	✓		

3.2. Milestones

Table 3.2. Milestones							
Milestone no.	**Milestone name**	**Work package no**	**Lead beneficiary**	**Delivery date from Annex I**	**Achieved Yes/No**	**Actual / Forecast achievement date**	**Comments**
M5.1	Website and Wiki pages set up and operational	WP5	ETHZ	M2	Yes	M2	

4. Project management

The basic concern of the management team for the first year was to put in place and enforce the use of all those tools and processes that can ensure a smooth collaboration amongst partners but also their commitment to the project research plan. In this direction, the management team has, on the one hand, applied best practices and, on the other hand, experimented with tools and processes that appear to help the everyday interaction within the project.

The management structure in ResumeNet involves two Committees, the Project Coordination Committee (PCC) with representation of all partners and the Project Technical Management Committee (PTM) with participation of WP leaders. This way management tasks are distributed amongst a number of partners rather than being concentrated on a single partner; of course, increased responsibilities and activities correspond to the people leading the two committees, Prof. B. Plattner, Dr. M. Karaliopoulos, and Prof. D. Hutchison. On top of this, the responsibility for certain administrative tasks of the project (finance data collection, documentation) lies with the EUresearch team in ETH Zurich, and more specifically, with Mrs. S. Hodel.

Through the first year of the project lifetime, significant resources were devoted to the set-up of proper management tools and processes to accompany the project along its full duration. More specifically, the management effort was directed in the following directions:

- **Setting up the required information infrastructure** to allow dissemination/exchange of information and the interaction of partners. This includes:

  - Project website: the project website (http://www.resumenet.eu) was set up already by early November to allow dissemination of project information. It experienced a major update in the end of August to provide more detailed information on the project activities and accommodate better the outcomes of the project research over the first year.

  - Wiki pages: the main tool for every day interaction of partners (http://wiki.resumenet.eu). It was made available together with the public website and has been heavily used for running the project, emerging as a valuable tool for progressing with the project work. Its content is daily enriched in accordance with the project Consortium needs. Both the public website and the Wiki pages are hosted by ETH Zurich.

  - Emailing lists: two emailing lists are hosted by the information services section of ETH Zurich for the ResumeNet project, one for the project assembly and one for the Technical Management Committee.

  - Subversion repository tool (svn): documents (deliverables, reports, presentations, and publications) are prepared using the svn tool made available by ETH Zurich (svn://svn.ee.ethz.ch/eu-fp7-resumenet)

- **Maintaining synchronization of the whole Consortium on the project activities**. In the first nine months of the project, the management of the project and the synchronization were largely achieved through a combination of Phone Conferences and newsletters. The Phone Conferences were organized every second Thursday amongst the members of the Technical Project Management team (WP leaders). They were used for reporting on the status and progress of all WPs and planning both WP-level and project-level actions. The first Phone Conference was run on Oct 2nd and till end of M12 (August) twenty (20) such PhCs had taken place. In parallel, an internal newsletter was prepared

and distributed to all Consortium partners (bi)-weekly summarizing the main facts and news about the project. This process was launched towards the end of the first half year of the project to help the synchronization of all partners with what is going on in the project. After the 2nd Plenary Project meeting, the process was revised. It was determined to open the bimonthly Phone Conferences to the full Consortium and use them for sharing information. Since the number of participants is higher, the scope of the Conferences was slightly revised. They serve more the purpose of information sharing and plenary-level decision-making. This is the process followed up to now; in each plenary meeting, the process is reviewed and corrective actions are taken.

Additionally, regular phone conferences are held at WP-level or even at task-level For WP3, for example, they take place monthly or bimonthly since June 2009, whereas more than 3 PhCs have so far taken place among all involved partners for the work on metrics in task 1.3.

- **Project monitoring**. A lightweight process is introduced with the purpose of enforcing respect of deadlines in the preparation of project deliverables and milestones. This involves the identification of important stages and dates in the progress of deliverables/milestones and the scoring of partners who have a role in those stages. The process was first tested in the preparation of M12 deliverables with moderate success.
- **Organization of physical meetings.** To set up the overall project work but also within individual WPs, three plenary meetings took place during the first year: the kickoff meeting in Zurich, 17-18 September 2008, the first plenary meeting in Heidelberg, Germany, 15-16 January 2009, and the second plenary meeting in Lancaster, UK, 10-12 June 2009. In parallel, three separate WP-level meetings took place in Passau, Germany, on November 7th to structure work with respect to challenges (task 1.2 and deliverable D1.1); Heidelberg, Germany, on March 18th, to focus work in WP2 and align it with the current directions in WP1; Munich, Germany, on May 7th to kick off work in WP3. The list of meetings scheduled for the interval September 2009-February 2010 is given below:

Table 4.1: Physical meetings envisaged over the next 6 months of the project

Meeting	Context (scope)	Date	Location/ Host
3rd Project plenary meeting[7]	The tri-annual plenary project meeting	7-9 October 2009	Munich, Germany (TUM), with a parallel meeting with the project Advisory Board
1st annual review meeting	Review meeting + brief project TPM group meeting to plan work after the review	29 October 2009	Zurich, Switzerland (ETHZ)
4th Project plenary meeting	The tri-annual plenary project meeting	20-22 January 2010	Delft, Netherlands (TUD)

- **Advisory Board set-up.** Additional effort has been devoted to the set-up of the project Advisory Board (AB), which can give valuable feedback to the Consortium regarding

[7] By the time this report was written, the 3rd project plenary meeting had taken place.

research outcomes and directions. A number of experts were identified and ranked by the Consortium as candidates for the AB. The aim has been to combine technical expertise in all areas addressed by the project, e.g., networking but also dependability/survivability and risk assessment, and different viewpoints to the network resilience question, i.e., both from academy/research but also from network operators. The four people identified as most relevant were contacted and accepted to take part in the consortium. They are listed in Table 4.2

Table 4.2: Members of ResumeNet Advisory Board

AB member	Context (scope)	Expertise
Ruediger Grimm	Professor for IT Risk Management at the University of Koblenz, Germany	IT security in general, digital rights management, fair use, e-voting and political participation, biometrics and privacy, e-commerce and trust
Jim Kurose	Distinguished University Professor, past chairman, Department of Computer Science, UMASS	network protocols and architecture, network measurement, sensor networks, multimedia communication, modelling and performance evaluation
Jean-Claude Laprie	"Directeur de recherche" at CNRS, the French National Organization for Scientific Research (LAAS), Toulouse, France	fault tolerance and dependable computing
Rick Schlichting	Head of the Software Systems Research Department at AT&T Labs-Research, Florham Park, New Jersey Adj. Prof. University of Arizona	distributed systems, highly dependable computing and fault tolerance, operating systems and networks

The first meeting with the Advisory Board took place in Munich, Germany, on October 9th, immediately after the end of the 3rd Plenary Project meeting. Three of the members (Ruediger Grimm, Jean-Claude Laprie, and Rick Schlichting) joined the meeting physically; Jim Kurose joined remotely with the help of a remote collaboration tool and Skype videoconferencing. The project Consortium presented to the AB members their work through the first year and got their advice on corrective actions that can be taken to improve the project.

So far the management of the project runs smoothly. No particular problems have emerged. There are changes neither in the Consortium nor in the status of beneficiaries.

5. Explanation of the use of the resources

Omitted from this version of the deliverable.

References

[ResD1.1]	Understanding challenges and their impact on network resilience. ResumeNet Deliverable D1.1, March 2009
[ANA]	http://www.ana-project.org. EU FP6 ANA project website
[INTER]	http://www.intersection-project.eu EU FP7 INTERSECTION project website
[ResD6.3]	Report of technical work in WP2 and WP3 during the 1st year. ResumeNet Deliverable D6.3, September 2009.
[TikNet]	http://tiknet.ee.ethz.ch/ The ETH Zurich TikNet Wireless Multihop Network testbed
[FIREW]	http://www.ict-fireworks.eu. The EU FP7 FIREWorks Coordination action website