Superfluidity:
a super-fluid, cloud-native, converged edge system

Call: H2020-ICT-2014-2
Topic: ICT 14 – 2014: Advanced 5G Network Infrastructure for the Future Internet

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Essential Project Data

- Budget: 7.9 M€
- Starting date: 1/7/2015
- Duration: 30 months
- Project officer: Remy BAYOU

Partners

Consorzio Nazionale Interuniversitario per le Telecomunicazioni	IT
Alcatel Lucent Bell Labs France	FR
Alcatel Lucent Israel	IL
British Telecom	UK
Citrix	GR
EBlink	FR
Intel Ireland	IE
NEC Europe	UK
OnApp	UK
Portugal Telecom Innovation and Systems	PT
Red Hat	IL
Telcaria	ES
Telefonica I+D	ES
Unified Streaming	NL
University Ben Gurion	IL
University of Liège	BE
University of Technology Dresden	DE
University Politehnica of Bucharest	RO

Scenario, a layman's view

- More people (world population is expected to reach 7.8 billion people by 2020, most of them moving and often crowding in relatively small areas)
- More interconnected devices (25 billions by 2020)
- More access networks, diverse, dense, mobile and unpredictably changing
- More diverse devices and applications
- Wider and faster network coverage (5G)

Scenario, a layman's view

- Revenue growth is expected to halve from now to 2020
  - overprovisioning, or even static provisioning in time and space, is out of question
  - energy consumption should be reduced
- Sharing and optimizing resource usage in time and space
  - benefits of virtualization
    - sharing: resources divided into multiple virtual pieces used by different users
    - isolation: sharing of a resource does not endanger security and privacy of users
    - aggregation: if resources are not big enough to accomplish a task, they can be aggregated
    - dynamics: reallocation of resources in space and time on demand
    - ease of management and evolution: software-based devices are easier to manage and update

Scenario, a layman's view

- Is this all about efficiency, cost reduction, performance improvement?
- Mainly, but also about application-driven network design, or integration of applications and networking
  - new classes of applications: face recognition, speech translation, expert systems
  - low latency: cloud providers bypassing ISPs
  - need of architectural rethinking: simply "moving" existing functional elements in NFV is not enough
- Application/service-centric network control able to dynamically share and allocate virtualized resources

Scenario, a layman's view

- Cloud networking: [wikipedia]
  - A networking paradigm for building and managing secure private networks over the public Internet by utilizing global cloud computing infrastructure
  - Traditional network functions and services including connectivity, security, management and control, are pushed to the cloud and delivered as a service
  - Network-as-a-Service (NaaS)

Scenario, a layman's view

- Cloud networking use cases
  - Network management (efficiency, cost reduction) and traffic control in the cloud
  - MAC in the cloud (e.g. how to manage thousands of WiFis in a skyscraper ?)
  - Machine learning
  - IoT: analysis of collected data in the cloud
  - 5G (mmWave, massive MIMO, cloud RAN, all baseband processing in a data center, convergence of wireless/wired access control, everything in one place, statistical multiplexing)
    - requirement=1Tbps, 1ms latency; current data center not designed for this scale (real time cloud computing)

Scenario, a layman's view

- The Cloud is transforming the Internet
  - 1G: portable
  - 2G: digital
  - 3G: data
  - 4G: Internet
  - 5G: cloud
- Internet->network of data centers
- Smartphone->access to artificial intelligence
- Communication model=computer-to-cloud-to-computer
  - diminishing need of computer to computer communications
    - Social networks are in reality communications to cloud not to other peers

Scenario, a layman's view

- Internet ->:
  - 1-hop access to cloud
  - thin access section
    - connect billions of users to the cloud(s)
    - new technologies (fiber, light)
    - infinite bandwidth
    - zero latency
    - IoT

Scenario, a layman's view

- Contrary to the design of the Internet
  - top down
  - owned by single company
  - intelligence and data in the core not in the edge
  - less interoperability issues and standardization needs
  - greater need of abstractions

[credits to Yongguang Zhang, Microsoft]

Scenario, a layman's view

- Software-defined networking (SDN)) [wikipedia]
  - A concept that allows network administrators to manage network services through abstraction of lower-level functionality
  - This is done by decoupling the system that makes decisions about where traffic is sent (the control plane) from the underlying systems that forward traffic to the selected destination (the data plane)
  - SDN requires some method for the control plane to communicate with the data plane. One such mechanism is OpenFlow

Scenario, a layman's view

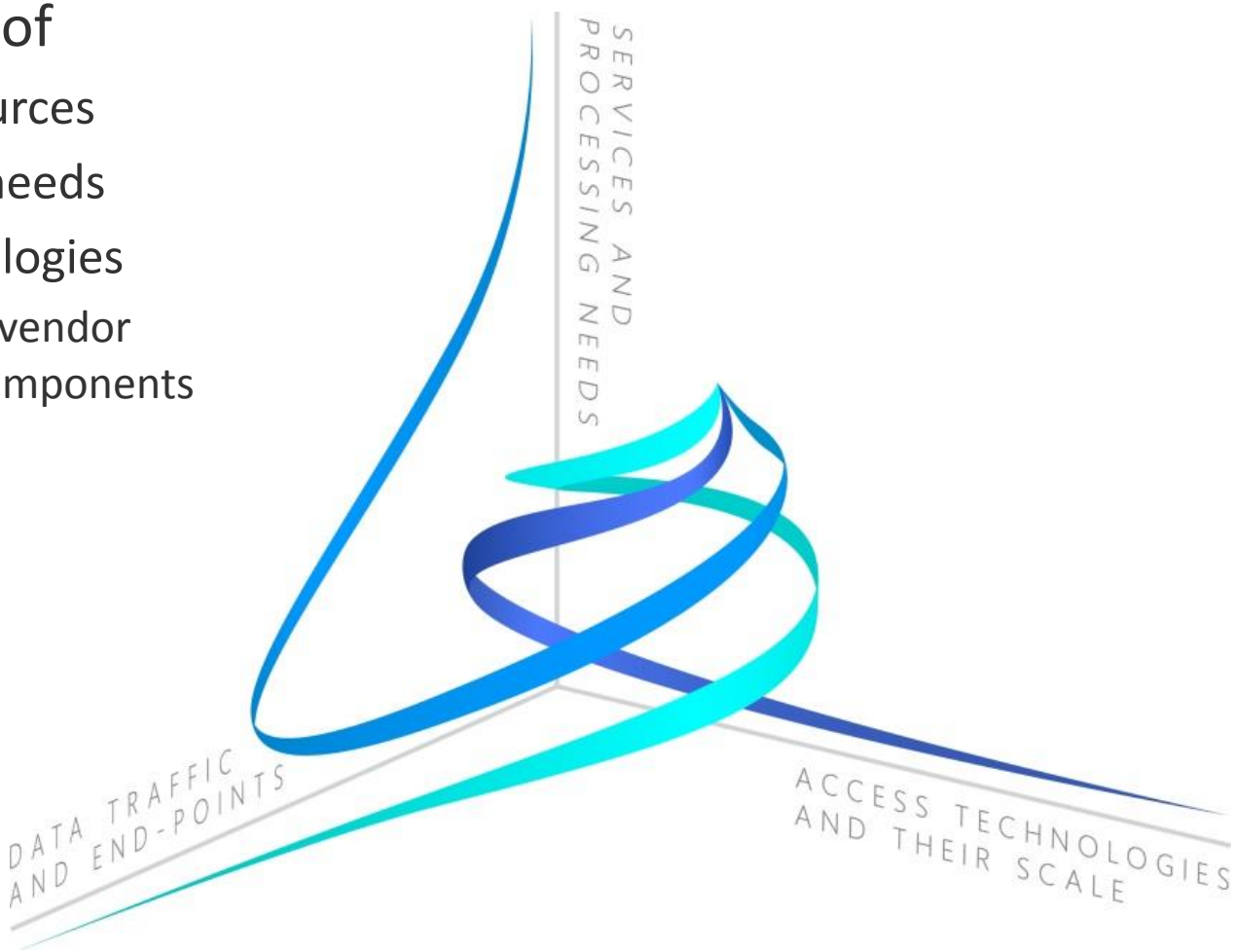
- Network functions virtualization (NFV) [wikipedia]
  - a concept that proposes using IT virtualization related technologies to virtualize entire classes of network node functions into building blocks that may be connected, or chained, to create communication services
  - a virtualized network function, or VNF, may consist of one or more virtual machines running different software and processes, on top of industry standard high volume servers, switches and storage, or even cloud computing infrastructure, instead of having custom hardware appliances for each network function
  - Examples:
    - a virtualized session border controller function could be deployed to protect a network without the typical cost and complexity of obtaining and installing physical units. Other examples include virtualized load balancers, firewalls, intrusion detection devices and WAN accelerators.

Project description

- Superfluidity in the network
  - instantiate services on-the-fly, run them anywhere in the network (core, aggregation, edge) and shift them transparently to different locations
- Tackling crucial today's shortcomings
  - long provisioning times
  - wasteful over-provisioning used to meet variable demand
  - reliance on rigid and cost-ineffective hardware devices
  - complexity, emerging from three forms of heterogeneity

Project description

- Heterogeneity of
  - traffic and sources
  - services and needs
  - access technologies
    - with multi-vendor network components



Project description

- Solution based on
  - decomposition of network components and services into elementary and reusable primitives
  - native, converged cloud-based architecture
  - virtualization of radio and network processing tasks
  - platform-independent abstractions, permitting reuse of network functions across heterogeneous hardware platforms while catering to the vendors' need for closed platforms/implementations
  - high performance software optimizations along with leveraging of hardware accelerators

Specific project goals

- Data plane processing architecture
  - A flexible, open and programmable 5G data plane processing architecture and relevant APIs for network functions' convergence
- Converged 5G platform
  - A unified and high performance distributed cloud platform technology for radio and network functions support and migration
- New Algorithms and functions
  - Algorithmic and design improvements for radio processing tasks, flow processing primitives, and service optimization
- Ultra-fast and efficient virtualization
  - beyond the state of the art, quickly instantiable, with low memory footprint, and high performance

Specific project goals

- Hardware adaptation and abstraction
  - technologies and interfaces to exploit and integrate customized hardware
- Control and provisioning framework
  - Extensions of existing and widespread frameworks for platform's management, control, and elastic provisioning
- Security framework
  - Security abstractions and mechanisms to control the access to, and execution of, the network processing functions, and to prevent third-party network functions from having a negative impact on other clients' functions, the network, or the Internet at large
- Contribution to standardization

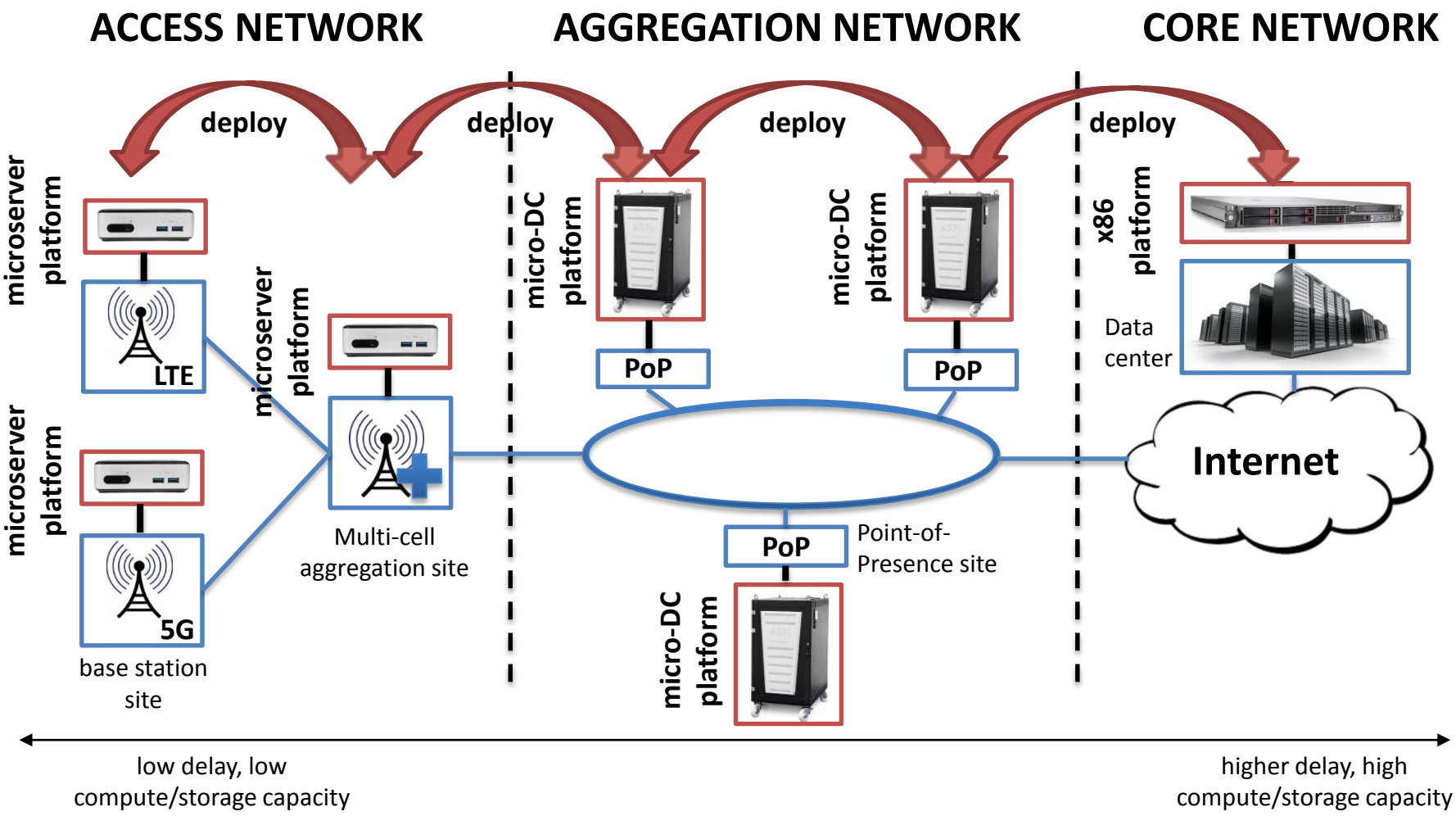
Main impact

- A converged cloud-based 5G concept that will enable innovative use cases in the mobile edge, empower new business models, and reduce investment and operational costs
  - Macro level: consortium partners aiming at strategically placing themselves as the driving force in the area of converged 5G service and network architectures by becoming early adopters of SUPERFLUIDITY's system

Main impact

- Societal level: enabling software and application providers to bring to the market innovative services and applications exploiting information on network capabilities and conditions available at the base station without worrying about the underlying hardware; the open application space will drive the quality of the service up and the costs down
- Operational level: i) deployment of service and applications close to users following their particular performance needs; ii) reduction of end-to-end latency; iii) development of 5G standards and production-quality open source code; iv) tools for system orchestration and management and for security, integrating the SUPERFLUIDITY system into one of the leading cloud management frameworks

Preliminary architecture



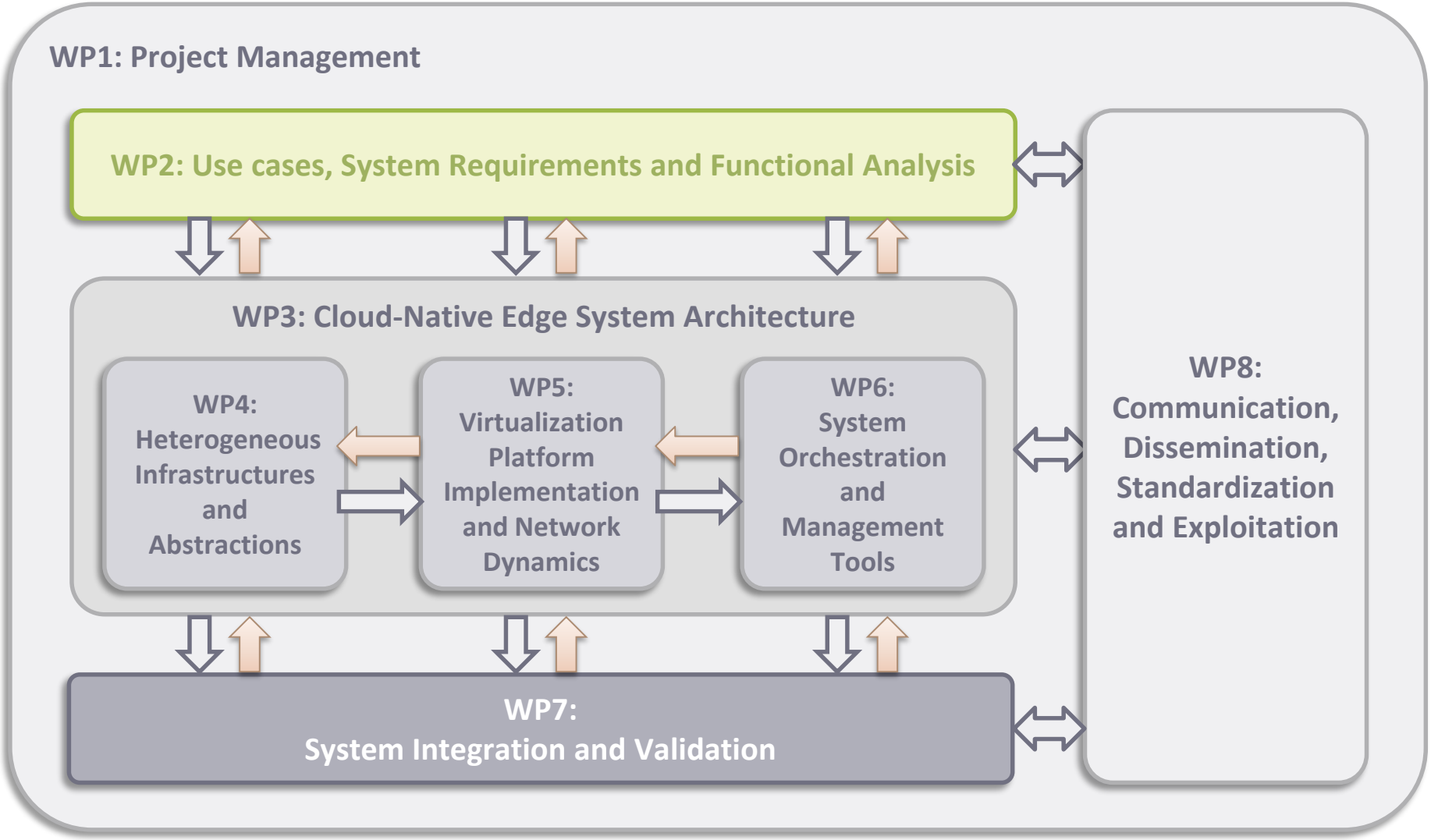
Preliminary architecture

- Physical view
  - a set of platforms (in red boxes) running on different types of hardware (microservers, small racks, larger x86 deployments)
  - set up next to base stations and aggregation sites in access networks, at micro data centers at Point-of-Presence sites in aggregation networks, and at full-fledged data centers in the core network
  - with multi-tenant and shared infrastructure; network processing can be instantiated by third parties on-the-fly, when and where it is needed
- The orchestrator
  - in charge of providing an API to platform users and of deploying the necessary network processing in a safe, high performance fashion
  - end-users, application developers and any tenant decide the trade-off between low-delay access near the edge (left-hand side of the figure) and high compute/storage capacity near the core (right-hand side)

Preliminary architecture

- Functional architecture
  - based on decomposing processing into basic functional blocks
  - parts of the 5G network offer hardware (black boxes) or software functions (red boxes), each with a clearly defined API
  - functional blocks used by operator and customers to deploy more complex processing that relies on combinations of the offered basic blocks

Work packages



Work packages

- WP1: Project Management
  - led by CNIT
- WP2: Use cases, System Requirements and Functional Analysis
  - led by British Telecom
- WP3: Architecture and Programming Interfaces Specification
  - system-wide architecture, application-platform services and management interfaces, node platform
  - “contains” the following three WPs, each of which caters for a specific level of the system
  - led by ALCATEL LUCENT

Work packages

- WP4: Heterogeneous Infrastructures and Abstractions
  - HW modelling, profiling and selection; performance, scalability and portability aspects of multiple hardware platforms
  - led by INTEL
- WP5: Virtualization Platform Implementation and Network Dynamics
  - solutions for platform-agnostic programmability and configuration, taking into account the dynamics of virtual network functions
  - led by NEC
- WP6: System Orchestration and Management Tools
  - provisioning and control framework, including automated security verification of network processing code
  - led by REDHAT

Work packages

- WP7: System Integration and Validation
  - led by Portugal Telecom
- WP8: Communication, Dissemination, Standardization and Exploitation
  - led by CITRIX

Gantt

If Starting date 1/7/2015:

		Jul-15	Aug-15	Sep-15	Oct-15	Nov-15	Dec-15	Jan-16	Feb-16	Mar-16	Apr-16	May-16	Jun-16	Jul-16	Aug-16	Sep-16	Oct-16	Nov-16	Dec-16	Jan-17	Feb-17	Mar-17	Apr-17	May-17	Jun-17	Jul-17	Aug-17	Sep-17	Oct-17	Nov-17	Dec-17
		Year 1												*Year 2*												*Year 3*					
WORKPLAN	**Leader**	Month 1	Month 2	**Month 3**	Month 4	Month 5	**Month 6**	Month 7	Month 8	Month 9	Month 10	Month 11	**Month 12**	Month 13	Month 14	Month 15	**Month 16**	Month 17	Month 18	Month 19	**Month 20**	Month 21	Month 22	Month 23	**Month 24**	Month 25	Month 26	Month 27	**Month 28**	Month 29	**Month 30**
WP1: Project Management	**CNIT**																														
T1.1: Project Procedures and Infrastructure	CNIT		D1.1																												
T1.2: Strategic Coordination	CNIT				PR1				PR2				RR1				PR3				PR4				PR5				PR6		RR2
T1.3: Technical Coordination	ALUIL												D1.2																		D1.3
T1.4: 5G-PPP Collaboration	CNIT																														
WP2: Use cases, System Requirements and Functional Analysis	**BT**																														
T 2.1: Use Cases Identification and Analysis	BT			I2.1						D2.1																					
T 2.2: Technical and Business Requirements	TID						I2.2																								
T 2.3: Functional Analysis and Decomposition for the Reuse&Sharing of Resources	ALBLF						I2.3					D2.2																			
WP3: Cloud-Native Edge System Architecture	**ALUIL**																														
T 3.1: System-Wide Architecture Specification	ALUIL									I3.1							D3.1														
T 3.2: Platform Agnostic Programming Interfaces Specification	CNIT																														
T 3.3: Security Framework Design	BGU									I3.2																					
WP4: Heterogeneous Infrastructures and Abstractions	**INTEL**																														
T 4.1: Hardware Selection, Modeling and Profiling	INTEL											I4.1												D4.1							
T 4.2: High Performance Block Abstractions Implementation	ONAPP																								D4.2						
T 4.3: Innovative Radio and Network Processing Functions	TUD																							D4.3							
WP5: Virtualization Platform Implementation and Network Dynamics	**NEC**																														
T 5.1: Optimal Function Allocation	ULG											I5.1												D5.1							
T 5.2: Network Services Dynamics, Performance and Scalability	NEC												I5.2												D5.2						
T 5.3: API Implementation	CITRIX																								D5.3						
WP6: System Orchestration and Management Tools	**REDHAT**																														
T 6.1: Provisioning and Control Framework	REDHAT											I6.1													D6.1						
T 6.2: Access-Agnostic SLA-Based Network Service Deployment	ALUIL												I6.2																		
T 6.3: Automated Security Verification Framework	UPB												I6.3																		
WP7: System Integration and Validation	**PTInS**																														
T7.1: Selection of Use Cases for Deployment and Field Trials	BT																					I7.1						D7.1			
T7.2: System Integration	PTInS																		I7.2										D7.2		
T7.3: Use Cases Validation and Assessment	ULG																								I7.3						D7.3
WP8: Communication, Dissemination, Standardization and Exploitation	**CITRIX**																														
T 8.1: Communication and Dissemination	CNIT						D8.1						D8.2								D8.4										D8.6
T 8.2: Open source contributions and standardiz.	REDHAT			I8.1																											D8.7
T 8.3: Innovation and Exploitation	CITRIX												D8.3								D8.5										D8.8
				M1			M2						M3				M4				M5				M6			M7			M8
													P1												P2						P3
													R1																		R2

List of deliverables

Deliverable (number)	Deliverable name	WP number	Lead particip.	Type	Dissemination level	Delivery date
D1.1	Project Management Manual	WP1	CNIT	R	CO	2
D1.2	Project Vision and Roadmap, v1	WP1	CNIT	R	PU	D=12
D1.3	Project Vision and Roadmap, v2	WP1	CNIT	R	PU	D=30
D2.1	Use cases, technical and business requirements	WP2	BT	R	PU	[I=3,6] [D=9]
D2.2	Functional analysis and decomposition	WP2	ALUBLF	R	PU	[I=6] [D=11]
D3.1	Final system architecture, programming interfaces and security framework specification	WP3	CNIT	R	PU	[I=9] [D=16]
D4.1	Hardware Selection, Modelling and Profiling	WP4	INTEL	R	CO	[I=11] [D=23]
D4.2	High Performance Block Abstractions Implementation	WP4	ONAPP	R/OTHER	CO	[I=11] [D=24]
D4.3	Innovative Radio and Network Processing Functions	WP4	TUD	R/OTHER	CO	[I=11] [D=23]

List of deliverables

Deliverable (number)	Deliverable name	WP number	Lead particip.	Type	Dissemination level	Delivery date
D5.1	Function Allocation Algorithms Implementation and Evaluation	WP5	ULG	R/OTHER	PU	[I=11] [D=23]
D5.2	Mechanisms for Network Service Dynamics and Performance	WP5	NEC	R/OTHER	PU	[I=12] [D=24]
D5.3	Platform API Design and Implementation	WP5	CITRIX	R/OTHER	PU	D=24
D6.1	System Orchestration and Management design and implementation	WP6	REDHAT	R/OTHER	PU	[I=11,12] [D=24]
D7.1	SUPERFLUIDITY use case scenarios for deployment and validation	WP7	BT	R	PU	[I=21] [D=27]
D7.2	System integration report	WP7	PTINS	R/DEM	CO	[I=18] [D=28]
D7.3	Validation, Assessment and Trial report	WP7	ULG	R/DEM	CO	[I=24] [D=30]
D8.1	Communication and Dissemination Plan	WP8	CNIT	R	PU	[I=3] [D=6]

List of deliverables

Deliverable (number)	Deliverable name	WP number	Lead particip.	Type	Dissemination level	Delivery date
D8.2	First report on Communication, Dissemination Actions, Standardization and Open Source Contributions	WP8	REDHAT	R	PU	D=12
D8.3	Innovation and Exploitation Plan	WP8	CITRIX	R	PU	D=12
D8.4	Second report on Communication, Dissemination Actions, Standardization and Open Source Contributions	WP8	REDHAT	R	PU	D=20
D8.5	First Report on Innovation and Exploitation Actions	WP8	CITRIX	R	PU	D=20
D8.6	Final Report on Communication, Dissemination Actions	WP8	CNIT	R	PU	D=30
D8.7	Final Report on Standardization and Open Source Contributions	WP8	REDHAT	R	PU	D=30
D8.8	Final Report on Innovation and Exploitation Actions	WP8	CITRIX	R	PU	D=30

List of milestones

Milestone number	Milestone name	Due date	Means of verification
1	Project fully operational	3	Management structures and procedures, including standard formats and forms for project documentation ready. Composition of boards and teams fully defined. Technological infrastructure to support cooperative work fully operational (web server, document server, version control system for sources files, mailing lists, management & report tools, etc.). First version of the use cases. Planning of Communication, Dissemination, Standardization and Exploitation activities
2	Intermediate Requirements and Functional Analysis	6	WP2 producing intermediate Technical and Business Requirements and Functional Analysis and Decomposition for the Reuse&Sharing of Resources. Early results on System architecture

List of milestones

Milestone number	Milestone name	Due date	Means of verification
3	End of phase 1	12	First project review; first edition of the Project vision and roadmap; first annual review report; final results from WP2. Stable system architecture; intermediate results from core WP 4, 5, and 6; first report on communication, dissemination and open source contributions and standardization and innovation and exploitation
4	Intermediate Requirements and Functional Analysis	6	WP2 producing intermediate Technical and Business Requirements and Functional Analysis and Decomposition for the Reuse&Sharing of Resources. Early results on System architecture
5	System architecture complete	16	Completion of the System architecture

List of milestones

Milestone number	Milestone name	Due date	Means of verification
6	End of phase 2 and completion of core technical WPs (4,5,6)	24	Platform components complete, initial platform available and demoed; Communication and Dissemination reaching wider audience.
7	System integrated	28	Platform integration and prototype available.
8	End of phase 3 and of the project	30	Second project review: second edition of the Project vision and roadmap; second annual review report; final release of platform and use case code; final report on dissemination and open source contributions and standardization.

Effort Table

	WP1	WP2	WP3	WP4	WP5	WP6	WP7	WP8	Total Person/ Months per Participant
CNIT	24	6	18	9	8	10	4	8	**87**
Alcatel Lucent Bell Labs France	0	10	16	4	0	0	6	0	**36**
Alcatel Lucent Israel	10	6	12	6	2	16	2	4	**58**
British Telecom	0	12	0	0	0	0	8	5	**25**
Citrix	2	4	6	6	28	18	6	8	**78**
EBlink	0	2	4	4	0	2	8	0	**20**
Intel Ireland	0	6	2	26	6	14	0	6	**60**
NEC Europe	0	8	10	12	27	0	8	6	**71**
OnApp	0	0	8	18	16	4	6	4	**56**
Portugal Telecom	0	7	6	0	10	10	18	3	**54**
Red Hat	0	3	0	0	13	22	2	12	**52**
Telcaria	0	3	3	4	8	10	0	4	**32**
Telefonica I+D	0	7	6	0	6	8	4	4	**35**
Unified Streaming	0	0	0	0	0	0	14	0	**14**
University Ben Gurion	0	4	10	7	0	8	5	0	**34**
University of Liège	0	0	9	10	18	0	16	3	**56**
University of Technology Dresden	0	2	0	14	12	4	3	1	**36**
University Politehnica of Bucharest	0	4	8	4	8	26	10	0	**60**
Total Person/Months	**36**	**84**	**118**	**124**	**162**	**152**	**120**	**68**	**864**

Role of partners

Partner	Type	Main role
CNIT	Research center	CNIT is the project coordinator. Focus on architecture, platform-agnostic abstractions and relevant API for data plane network functions
Alcatel Lucent Bell Labs France	Telco Industry	ALBLF will: i) develop a RAN framework; ii) define new service categories and new wireless techniques; iii) improve virtualization tools; iv) specify the architecture; v) prototype end-to-end connection, vi) demonstrate new "5G services"; vii) instantiate API for network operator to control the orchestration of the "5G RAN as a service".
Alcatel Lucent Israel	Telco Industry	ALUIL includes two groups: Cloudband Business Unit and Bell-Labs Israel. The CloudBand Business Unit is developing a pioneering, market-ready platform to enable NFV. ALUIL will focus on the system requirements and architectural work as well as specifying the platform services and the programming interfaces. Bell-Labs will focus on designing schemes for QoS and SLA provisioning for NFV applications.
British Telecom	Network Operator	BT will support the whole project value chain from definition of use cases to exploitation. BT has been engaged with NFV from its inception and was one of the companies which established the concept and founded the ETSI ISG. BT will exploit NFV to support the integration of heterogeneous access networks and technologies
CITRIX	IT Industry	CITRIX will contribute to design and deploy an innovative and consistent virtualized product and service framework primarily addressing the convergence challenges
EBlink	SME	EBLINK's innovative Wireless Fronthaul solution represents a major technological advance in mobile network deployment, eliminating the last few hundred meters of fiber that are so costly for operators. EBLINK will trial his solutions together with Alcatel-Lucent, and mobile networks operators embedding the SUPERFLUIDITY results in the management of heterogeneous access networks

Role of partners

Partner	Type	Main role
Intel Ireland	IT Industry	Intel will lead the Infrastructure WP focusing on exposing details of platform hardware and software features including specialisations, accelerators or configuration specifics. Intel will also contribute to the Orchestration work package, leading a task that effects the interface from orchestration to infrastructure selection and management
NEC Europe	Telco Industry	NEC will continue its work towards high performance virtualized networking, with the aim of meeting 5GPPP requirements such as ultra-low delay, high throughput and low energy and space footprints. Further, NEC will help in defining and implementing novel use cases and helping to integrate the above technologies into a common system.
OnApp	SME	OnApp will investigate and develop high speed network packet forwarding to improve storage, network and overall performance of data centers and in particular Cloud workloads
Portugal Telecom Innovation and Systems	Network Operator	PTInS will lead the integration work where it will leverage the experience coming from its Cloud Unit that deployed the PT brand-new data center (https://cloud.ptempresas.pt). Support of projects use cases
Red Hat	IT Industry	REDHAT will focus on enabling the virtualization infrastructure manager ability to provision project components in a way that uses available cloud resources including hardware accelerators. As a major player in the OpenStack community, REDHAT will push for the necessary changes/adaptations in the OpenStack implementation to enable SUPERFLUIDITY to be implemented on top of OpenStack
Telcaria	SME	Telcaria will work on applied software and virtualization techniques, integrating the platform with existing cloud

Role of partners

Partner	Type	Main role
Telefonica I+D	Network Operator	TID will participate with two teams, one focused on RAN aspects and the other on NFV. TID will work on extending the virtualization of the network infrastructure to the radio access network
Unified Streaming	SME	USTR will participate in and test a selection of SUPERFLUIDITY use cases using its OTT streaming video solutions at the edge level (late transmuxing) with specific attention to the use of protection (DRM) at this level
University Ben Gurion	University	BGU will focus on design and evaluation of novel coding and optimization solution in the RAN and related services as well as on the design of new algorithms for anomaly detection, system validation and security
University of Liège	University	ULG will be involved in the definition of the abstractions, design and implementation of the network processing platform, as well taking part in the integration, validation and assessment work
University of Technology Dresden	University	TUD will contribute to the project with its expertise in wireless communications protocols and associated signal processing architectures. TUD will contribute in the aspect of open Cloud-RAN architecture, particularly, in the adoption of the virtualization techniques to baseband stack processing and in the definition of open control and computation APIs enabling integration of third party protocol stacks.
University Politehnica of Bucharest	University	UPB will be one of the main contributors to the work of enabling security of processing via static analysis. UPB will draw on its experience on static analysis and formal methods (Symnet work), security (WIT).

Thank you. Questions?

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