Workshop on the Future Internet Public Private Partnership Architecture– University of Piraeus Position Paper

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1. Introduction

This document is a position paper of the University of Piraeus (University of Piraeus Research Center – UPRC). It is intended for the Workshop, conducted in the context of the European Future Internet Initiative (EFII) [1,2], on the "Future Internet Public Private Partnership Architecture" [3], which will take place on the 9th of June 2010, in Madrid, Spain.

During the Presidential conference "The European RTD Framework Programmes: from economic recovery to sustainability" in October 2009, a Future Internet Public - Private Partnership (FI PPP) [2] was launched. One of the first accomplishments of the FI PPP is the development of the FI Core Platform (FI CP) [4], which will enable the creation, deployment and execution of applications. The FI CP will be an aggregation of computing, storage, communication and management capabilities (software supporting functions) that are combined in an orderly manner, according to an architecture. An architecture is seen as the structure of a system and the interrelationships between its parts. The workshop will discuss on this architecture.

The document addresses the five issues and open questions on the architecture, which will be addressed during the Workshop.

2. Responses to the Issues and Open Questions

2.1 Critical analysis of the proposed architecture

It is imperative that the FI CP addresses the following critical aspects:

- Support the *requirements from the numerous applications and services* that need to be provided, as the Internet has become one of the most integral parts of our professional, personal and social lives.
- *Exploit*, in the most *efficient* manner, a *powerful network infrastructure*.

Requirements from application areas. The application areas comprise multimedia communications, entertainment, the management of critical infrastructures and of our eco-system, smart transportation and energy, the support of enterprises and organizations that create value by manufacturing products or providing digital services (e.g., in the area of assisted living, learning, working, health). In all cases, application/service provision involves diverse environments/locations (e.g., home, public, work, urban, rural, etc.), times, paradigms regarding the communication end-points (e.g., machine-to-machine, machine-to-human, etc.), and information flows.

Therefore, the FI CP should be capable of:

- Handling demanding situations, requiring diversified levels of QoE (Quality of Experience) and end-to-end QoS (Quality of Service), in a manner that is context-aware, personalized and seamless. QoE/QoS are associated with availability, performance, reliability, accountability, trust and security.

- Handling situation changes, in order to guarantee continuity of experience and ubiquitous provision of the QoE/QoS levels in the various environments/locations and times.

Situations may be demanding as a result of the continuously growing interest for IP-based video (e.g., Over-the-top TV/video, IPTV) and voice (e.g., VoIP, voice-conferencing), or, for instance, because of the need for timely and reliable delivery of (potentially) low volumes of highly important data (e.g., for health or finance services). Context awareness ensures that the information on the involved locations/environments, times, communication end-points, and information-flows is taken into account. Personalization ensures that the requirements and capabilities of communication end-points and information-flows are taken into account. Seamless provision abstracts the complexity of the underlying infrastructure, devices and services. Sample causes of (anticipated or unpredicted) situation changes can be mobility, alterations in the traffic behaviour of communication end-points (humans or machines), or faults that can occur throughout the network.

Efficient exploitation of the infrastructure (computing, storage, telecommunication devices). The communication market is highly competitive. A high rate of price reductions continues to be witnessed. Therefore, cost-efficiency in QoE/QoS provision is required. Efficiency is coupled with reductions in the capital expenditures (CAPEX) and operational expenditures (OPEX), or total costs of ownership in general. Additionally, decisions with a "green" footprint (e.g., low energy consumption, electromagnetic transmissions, etc.) should be sought. Energy costs account for a significant part of operators' operating expenses, so network solutions that improve energy-efficiency are not only more than essential for the environment, they also allow cost reductions that make the business sustainable.

Telecommunication networking will include a heterogeneous technologies, e.g., LTE/2G/3G/WiMAX/WiFi/etc., xDSL, FTTx, Ethernet, IPv4/IPv6, MPLS, GMPLS, IMS, etc. The infrastructure will be organized in multiple business and administrative domains. The network nodes can be classical networks elements and terminals, various sensors and actuators, different "white" or "brown" devices, in general all types of "things" existing in our ambience. This heterogeneous infrastructure offers numerous options for satisfying QoE/QoS requirements. This is an outcome of the different technologies, devices and networks that can be found in alternate end-to-end paths connecting communication end-points.

In the light of the aspects highlighted in the previous paragraphs, the FI CP should seek and exploit the most efficient options, regarding technologies, devices and networks, for satisfying QoE/QoS requirements. This will represent a radical shift from legacy approaches, which typically rely on worst-case based planning, resulting in the over-provisioning of bandwidth, as well as on management that requires, to a very large extent, manual/human intervention.

Summary. The FI CP will need to handle multiple, demanding and changing situations for the provision of QoE/QoS levels, and will need to the exploitation of the infrastructure for increased efficiency in QoE/QoS provision.

2.2 Recommendations for advanced components and implementation options

Main features on the FI CP should be:

- Highly sophisticated management functionality;
- Mix of evolutionary and revolutionary networking technologies in the infrastructure.

Infrastructure. Taking an overall view, the FI CP will consist of heterogeneous technologies, multiple network segments, as well as various administrative and business domains. A representation of the proposed architecture is depicted in the following figure. It includes: (i) intelligent devices [5]; (ii) various types of access networks; (iii) diverse core networks; (iv) application and content segments.

The access segment includes 3GPP, non-3GPP and WiFi technologies, as well as wireless sensor networks. Moreover, the existence of efficient structures for accessing the Future Internet should be noted. A solution in this direction comprises opportunistic networks, which can be operator-governed (through the provision of spectrum, policies, information and knowledge), temporary, coordinated extensions of the infrastructure that may include network elements, and devices potentially organized in an ad-hoc networking manner.

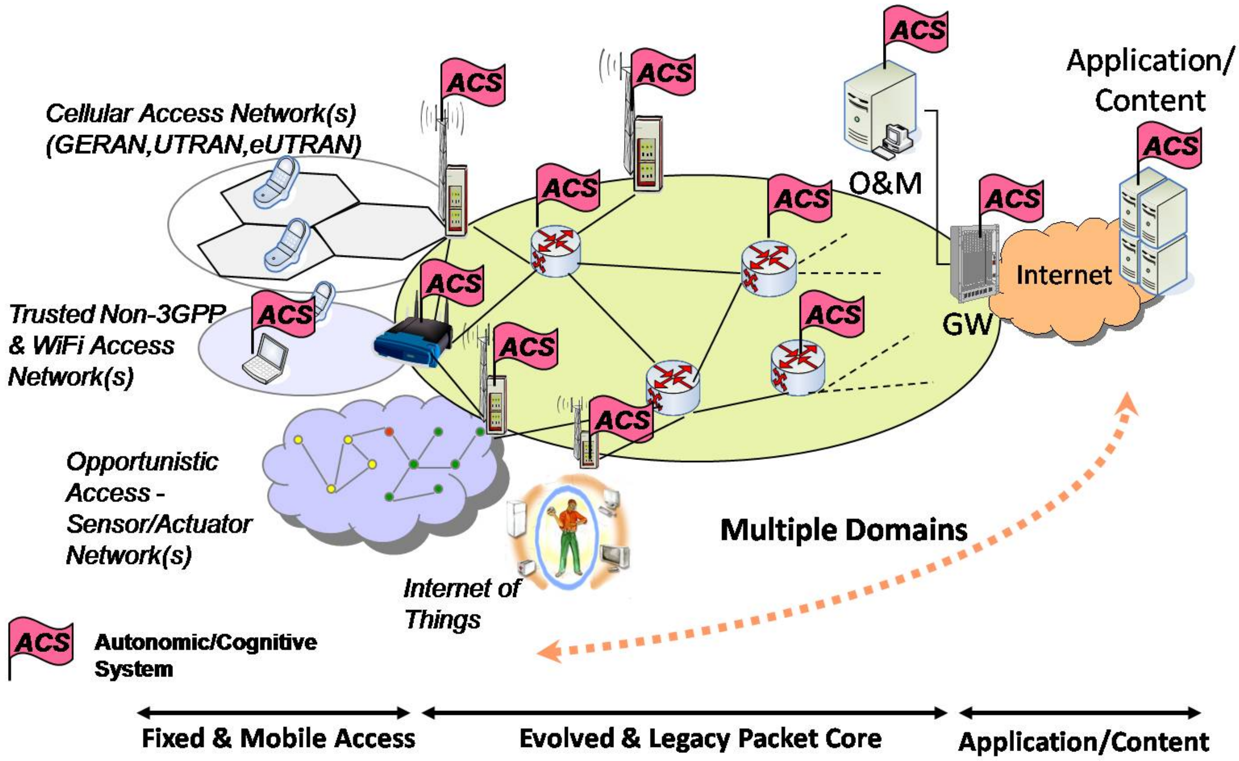

Figure 1. A representation of the FI architecture

Management. The FI CP should provide highly sophisticated management functionality. Cognitive/autonomic systems [6,7,8] are seen as a viable and promising direction for basing the management of services and infrastructures of the FI era. In general, the diverse applications/services and use cases that can be supported demand QoE/QoS guarantees, lead to changing (often unpredictably) situations, and call for resource efficiency. Cognitive/autonomic systems are suitable for basing the management due to their self-management and learning features. Self-management (configuration, optimization, healing, protection) is essential for fast adaptations to changing situations, and also for finding efficient ways for satisfying requirements, with respect to mere over-provisioning of bandwidth or manual management. Learning can increase the reliability and speed of decisions, by developing and considering knowledge and experience, for instance, on situations encountered, on how they were handled, and on the efficiency of the handling.

Cognitive/autonomic systems can be deployed at the level of the access points, routers in the core network, gateways in the various network segments and business or administrative domains, and in the "operation and management" level (which target the aggregate management of a portion of the network). A cognitive/autonomic system comprises context acquisition and reasoning, the derivation and evaluation of policies, distributed optimization techniques, and learning for acquiring and sharing knowledge and experience. Cognitive/autonomic systems call for platforms (implementing frameworks) that will enable the federation between systems of various domains, governance, dynamic embodiment (deployment, integration, orchestration) of functionality.

The following are some of the main problems that can be resolved through cognitive/autonomic management systems:

- Cognitive/autonomic management of the wireless access network;
- Distributed traffic engineering, focusing on inter-domain cases for offering end-to-end QoE/QoS.

The solution to the problems above is underway in the context of research and development initiatives. The FI PPP can boost the exploitation possibilities.

2.3 How to ensure we are "future" oriented and not implementing today's Internet services

The following essential aspects will guarantee that we are future oriented.

- Support of application areas and use cases mentioned above.
- There is a set of *validation criteria* that will ensure and expose the progress with respect to today's Internet, both qualitatively and quantitatively. These criteria may be related to the levels of: availability, reliability, ease of use (seamlessness), CAPEX/OPEX, total cost of ownership, "green" footprint, accountability, trust and security.

The list above can be defined from the early phases of the use case definitions. Validation with respect to the criteria can be conducted at all stages (e.g., design, development and testing, experimentation) of the engineering of the systems.

2.4 Relevant assets your R&D centre could contribute

The assets of our institution include the following aspects:

- Architecture [9,10,11,12] design, specification, and validation with respect to requirements, signaling load, computing requirements;
- Optimization of wireless and wireline networks [13,14,15,16,17];
- Context awareness and profile management [18], governance through policy-based management [19,20];
- Management based on machine learning and knowledge management techniques [21,22,23,24,25];
- Management platforms, ontologies, implementation of architecture and integration of functionality;
- Validation (relevant samples in [26,27]) through prototyping, demonstration and experimentation, as well as participation in pilots and trials;
- Business aspects [28], application scenarios and use cases [29,30,31,32,33];
- Standardization initiatives [34,35,36,37,38], namely in the context of ETSI TC RRS, ETSI ISG AFI, IEEE SCC41 P1900.4.

Our institution has been active in research and development, at the European and international levels, in FP6, EUREKA/CELTIC, FP7 (details on overall initiatives can be found in [39]). Members of our institution have extensive expertise in the research and development frameworks FP5, ACTS, RACE I and II, BRITE/EURAM, EURET.

Commercial exploitation of research results is a strategic target for our institution. In this respect, the involvement and contribution to the FI PPP constitutes a compliant strategic target.

2.5 Relevant experimentation facilities available

The experimentation facilities available are summarized in the following:

- Fixed access switches;
- Wireless access points and bridges;

- Core switches;
- Wireless backhauling;
- Routers with VoIP capability;
- Servers (hosting applications and content);
- Network management system;
- Emulators, simulators, environment condition generators.

Sample scenarios that can be supported include

- Alterations in the traffic requirements;
- Generation of faults;
- Alterations in the policies of a stakeholder (e.g., operator, regulator, etc.).

The list of scenarios can readily be complemented and be tailored to specific requirements. The testbed that is formed by the various available experimental facilities will be federated in the context of the Future Internet Research and Experimentation (FIRE) initiatives.

A sample arrangement of the testbed (close to the current situation) is depicted in the following figure.

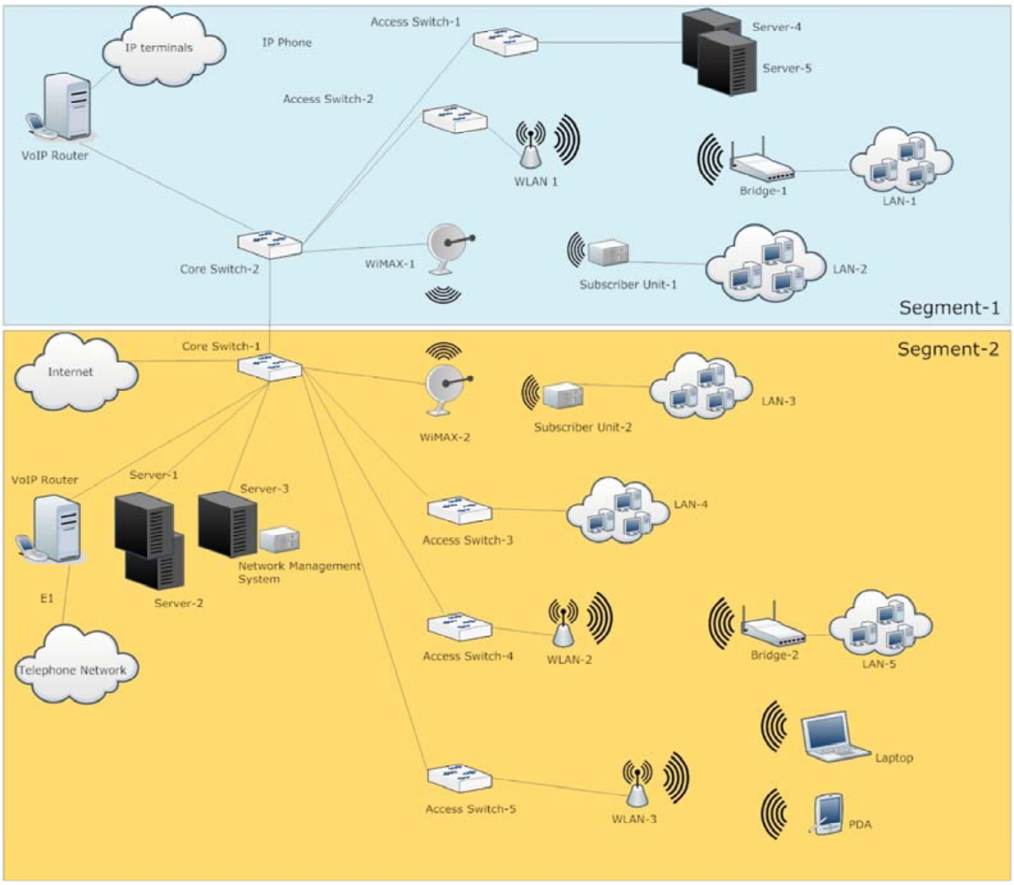

Figure 2. Sample arrangement of UPRC testbed

3. Summary

This document is a position paper coming from the University of Piraeus.

The document is intended for the "Future Internet Public Private Partnership Architecture" workshop.

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