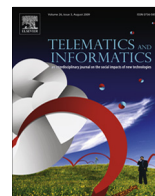




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Assessment of socio-techno-economic factors affecting the market adoption and evolution of 5G networks: Evidence from the 5G-PPP CHARISMA project

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ABSTRACT

5G networks are rapidly becoming the means to accommodate the complex demands of vertical sectors. The European project CHARISMA is aiming to develop a hierarchical, distributed-intelligence 5G architecture, offering low latency, security, and open access as features intrinsic to its design. Finding its place in such a complex landscape consisting of heterogeneous technologies and devices, requires the designers of the CHARISMA and other similar 5G architectures, as well as other related market actors to take into account the multiple technical, economic and social aspects that will affect the deployment and the rate of adoption of 5G networks by the general public. In this paper, a roadmapping activity identifying the key technological and socio-economic issues is performed, so as to help ensure a smooth transition from the legacy to future 5G networks. Based on the fuzzy Analytical Hierarchy Process (AHP) method, a survey of pairwise comparisons has been conducted within the CHARISMA project by 5G technology and deployment experts, with several critical aspects identified and prioritized. The conclusions drawn are expected to be a valuable tool for decision and policy makers as well as for stakeholders.

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1. Introduction

We are currently witnessing a tremendous increase in the use of mobile devices. In the near future, mobile devices are also expected to be connected to a wide range of other devices such as sensors. The number of connected devices is estimated by several industry analysts to rise from 20 billion to 100 billion by 2020.¹ In addition, ever more bandwidth hungry applications and services are constantly being developed. Although these applications can be supported by current mobile

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¹ <http://www.businessinsider.com/75-billion-devices-will-be-connected-to-the-internet-by-2020-2013-10>; <https://www.abiresearch.com/market-research/product/1016390-over-30-billion-wireless-connected-devices/>; 'Forecast: The Internet of Things, Worldwide 2013', Gartner, 2013; 'The State of Broadband 2012: Achieving digital inclusion for all', Broadband commission, 2012; 'The Internet of Things: How the next evolution of the Internet is changing everything', Cisco Systems, 2011; 'Towards 50 Billion Connected Devices', Ericsson Research, 2010; <http://www.itpro.co.uk/626209/web-connected-devices-to-reach-22-billion-by-2020>.

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broadband networks, future applications will impose additional stricter requirements that cannot be supported by the current networks. Furthermore, optical wired networks that could be used in order to accommodate the above requirements are characterized by their high deployment costs. Thus, 5G networking seems to be the only means in order to support both high performance and device heterogeneity (First Vision and Societal Challenges WG Brochure, 2015).

5G is a continuously evolving and very broad concept (C.V. Report, 2015) covering many different aspects. On the one hand, there are the quantifiable technical aspects such as: the expected end-user high bandwidths (e.g., 1–10 Gb/s to end-users), low latency (1-ms access times), and the ability to network a very high number of devices in a small geographic location. On the other hand, the more functional features of 5G such as fixed-mobile convergence, device-to-device (D2D) communications, ad-hoc meshing, and Open Access are also justifying the high global interest in 5G research currently occurring. Indeed, each of these various 5G features mentioned here are very large subjects in their own right; with many directions of research into each of these new technologies, new functionalities, and new means to improve efficiencies (e.g., energy efficiency, use of scarce network resources, improved CapEx, OpEx, and Total Cost of Ownership (TCO) profiles).

Changes at the network edge are a specific characteristic of the new 5G architectures, particularly as they absorb the recent advances in cloud computing, software defined networking (SDN) (Haleplidis et al., 2015) and network functions virtualization (NFV) (Liang and Yu, 2015). Softwarization and virtualization of networks, as well as the use of general purpose computers instead of specialized devices, enable the automation of network service provisioning and management, and facilitate the introduction of new network functions into the value chain leading to significant cost reductions, increased flexibility and more efficient use of resources.

5G network infrastructures are also anticipated to a critical asset that will support observed societal transformation, leading to the fourth industrial revolution (Second Vision and Societal Challenges WG Brochure, 2016). It will also impact multiple sectors and enable vertical sectors (Factories of The Future, Automotive, Health, Energy and Media & Entertainment) to enter the value chain and generate revenues. It is expected that 5G networking will offer various social impacts, such as better rural/urban integration, decentralization of work, reduced physical mobility needs, reduced CO₂ emissions, increased security, better and more complete entertainment, better social inclusion, increased wellbeing, enhanced medical support, fewer accidents and enhanced life experience for older people (G.W. Report, 2015). Apart from the social impact, 5G is also expected to significantly contribute towards the EU and Global economy by increasing countries' GDPs and creating hundreds of thousands of new jobs.²

All these many facets contribute into creating a very complex landscape with many possibilities for successful innovation and new business opportunities. However, navigating such a futuristic landscape, with so many unknowns and as yet untried and untested technologies, concepts and services, becomes a very risky business venture. In order to mitigate some of the business risks involved in investing in 5G technologies, a better understanding of the many issues surrounding the 5G business context is vital.

The objective of CHARISMA, a Research and Innovation project financed within the 5G Public-Private Partnership (5G-PPP) initiative by the European Commission (Horizon 2020 program), is the development of an open access, converged 5G network, via virtualized slicing of network resources to different service providers (SPs), with network intelligence distributed out towards end-users over a hierarchical architecture. Such an approach offers a means to achieve important 5G key performance indicators (KPIs) related to low latency, high and scalable bandwidths, energy efficiency and virtualized security (v-security). CHARISMA's ambitious approach for low latency and enhanced security builds upon present and future high-capacity developments that are currently being mooted for 5G deployment, such as 60 GHz/E-band, CPRI-over-Ethernet, cloud-RAN, distributed intelligence across the back-, front- and perimeter-haul, ad-hoc mobile device interconnectivity, content delivery networking (CDN), mobile distributed caching (MDC), and improved energy efficiency.

This paper aims to assess and prioritize several crucial technological and socio-economic issues that are expected to influence the deployment and market adoption of the CHARISMA solution in particular and 5G networks in general. This evaluation is carried out through a number of surveys conducted using elements of the Fuzzy Analytical Hierarchy Process (Fuzzy AHP) framework, and more specifically pairwise comparisons. This paper is mainly addressed to a technical audience, but it also aims to motivate the interest of a general audience in the CHARISMA solution and future 5G networks in general. The obtained results will be a valuable tool for policy and decision makers, in order to accelerate the successful deployment of 5G networks and increase their market adoption.

The rest of the paper is organized as follows: In Section 2, the fuzzy AHP methodology is presented. The survey design, along with the derived hierarchy and the defined criteria and sub-criteria are described in Section 3. Section 4 presents the results obtained by the surveys providing a discussion on their impact for 5G networks deployment. Global priorities and policy implications are given in Section 5. Some concluding remarks, limitations and future works are provided in Section 6.

2. Fuzzy AHP method for prioritizing critical factor for 5G adoption

The Analytic Hierarchy Process (AHP) was proposed and developed by Saaty (1977) in the early 1970s mainly for military purposes. AHP can be considered to be a multi-criteria decision making methodology, with AHP extensively used over the

² 5G Infrastructure Public Private Partnership (PPP): The next generation of communication networks will be Made in EU, European Commission, Digital agenda for Europe, February 2014.

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