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DELIVERING 4G (LTE) TO 5G MIGRATION WITH SUPPLY CHAIN MANAGEMENT

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ABSTRACT

The vulnerability of 5G telecom deployment cost with increased spectral efficiency, and new heterogeneous dense network deployments offers a big challenge in technology migration from 4G (LTE). Supply chains exist in both Mobile Service Providers (MSP) and Mobile Equipment Providers (MEP), although the complexity of the chain may vary greatly from MSP to MSP and MEP to MEP. In 5G purview, realistic supply chains have multiple end products with shared components, facilities and capacities. In this paper, we explore the effect of migrating legacy 4G MSP deployments into 5G to conform the e-governess needs. SDR applications algorithms from large form factor devices to the smaller one such as handheld mobile devices known as Elasticity Conscious Mobile Service Provider Systems (EConMSP). Our EConMSP framework concentrate on existing MSP infrastructure Volatility, including inherent migration complexity and the implementation. We expose our result for Migration Indictor (MI) in-terms of Device Dependent (DD) or Device Independent (DI) Transformation Steering Factors (TSF), such as Device Reconfiguration factor, Device Interoperability and their relation to inter-MSP or intra-MSPs Volatility. The impact of migration TSF is discussed for diverse mobile multimedia services obtained from standard vendors, OECD, Qualcom, to name a few; at the online website. Migration parameters are optimized against the native MSP services, while switching between different transformation schemes. Our results show that to conform with the 5G e-governess, the MSP infrastructure Volatility can be minimized by using an MSP-centric cost elasticity that enables both the effective use of underlying hardware architectures and the User Equipment (UE) access completely transparent to them. The robustness of our Elasticity Conscious Mobile Service Provider System (EConMSP) framework indicates 5G resource allocation problem in SCM must be decentralized when considering a practical application migration.

KEYWORDS: Supply Chain, Vulnerability, 5G, e-Governess, LTE, Technology Migration, SDR, Cost Elasticity

INTRODUCTION

Paving the way to 5G (5th Generation Telecom) entails both evolutionary and revolutionary system design, reduction in migration cost eventually. The innovations on this roadmap mainly include improving the SE and the area capacity while reducing the network operational cost to ensure fixed marginal cost for the operators Chung et. al, (2013), Yeganeh et. al, (2013).The core dynamics indicated by Saghezchi et. al, (2013), Shiller et. al, (2012), Abanger et. al, (2010 in mobile phone technology industrial landscape is the mobile operators; Mobile Equipment Providers (MEP) and capabilities of Mobile Service Providers (MSP). These mobile operators capabilities are the collective physical facilities, resources and human skills and knowledge that are timeshared and are brought together in a powerful mix through multitude of multimedia functions and ICT to effectively compete in markets across the globe. The mobility in such architectures remains transparent to UEs. As mobiles handover is soft to another MSP when detecting two or more cells from different node (Tower Antennas).

Unlike Basta et. al, (2013), Chung et. al, (2013), and Ghosh et. al, (2010), we explore following aspects of application expression as compared to conventional techniques:

- **The impact of** MSP-to-MSP communications ((M2M) exploiting **and migration implementation:** These effects are directly related to MSPs re-configurability volatility as depicted in Figure 3.1 and hence the # of calls and air-time performance.
- **Integration in intra MSPs Native Environment (MNE).** That utilizes the conventional MSP deployment to produce Always Available Always Connected (A2OC) efficient unified MSPs.
- Results are exposed all kinds of services and applications, from low throughput rates (e.g. sensor and IoT data) to higher ones (e.g. high-definition video streaming).

The remainder of this paper is organized as follows.

Next section is laying down the foundation of introduction to Internet on Things (IoT), is just about every physical object as e.g. clothes, cars, trains, etc. will also be connected by the end of the decade. Relevant research on the deployments and indices, what we mean by the term "deployment parameters" in CDIs estimation and optimization is summarized in the next section.

A detailed role of Deployment Parameters (DP) in migration and a successive transformation methodology is proposed in Section III. Good performance which usually means a good connectivity as well as Ghosh et. al, (2010), Greene et. al, (2009), and Liu et. al, (2012), defines Always Available, Always Connected (A2OC) © benefits Experimental results are reported in Section IV.

Finally in Section V we draw some conclusions and outline extensions as well as improvements to our future work.

RELATED RESEARCH

According to Chung et. al, (2013), Castruccci et. al, (2011), and Colitti et. al, (2011), it is only when these various characteristic elements are carefully coordinated and seamlessly integrated that economy of scale and scope manifest themselves with new innovative every imaginable technological growth, abilities, potency, resourcefulness and deftness. Traditional Fourth Generation (4G) skills that were used to manage MSP's are no longer valid in inter-MSP networks and new skills have to be learnt and new knowledge acquired by understanding the mechanisms and joint behavior through which these new organizations will flourish Castrucci et. al, (2011), OpenStak et. al, (2014), Saghezet. al, (2013),. The critical task for management, as with single large MSP, is to unify the organization such that its totality is more than equal to the sum of its component parts. An Ericsson study is expecting a 40x increase of data traffic from mobile phones and mobile personal computers (PCs)/tablets between 2010 and 2015. Also, the Cisco forecast in Qualcomm et. al, (2013), of the use of IP networks by 2017 revealed that Internet traffic is evolving from a steadier to a more dynamic pattern. The global IP traffic will correspond to 41 million DVDs per hour in 2017 and video communication will continue to be in the range of 80–90% of total IP traffic.

In this context, just about every physical object we see (e.g. clothes, cars, trains, etc.) will also be connected by the end of the decade, creating the Internet of Things (IoT), Theodorisdis et. al, (2013), Yeganeh et. al, (2013), entailed with exploration of new access path or migration from the present infrastructure keeping minimum revenue and investment in US$ for total mobile communication solution.

Figure 1.1 exemplify (per US million Dollar) growing trend to Machine-to-Machine communications ((M2M) exploiting sensor-based networking resulting in an additional driver for traffic growth. The drivers of the future Internet are all kinds of services and applications, from low throughput rates (e.g. sensor and IoT data) to higher ones (e.g. high-definition video streaming), that need to be compatible to support various latencies and devices. For example, Voice over IP (VoIP) applications require having at most 150 ms of delay, 30 ms of jitter and no more than 1% packet loss in order to maintain an optimal user-perceived Quality of Experience (QoE) referred in Saghezchi et. al, (2013). Interactive video, or video conferencing streams, embed voice calls and thus have the same service level requirements as VoIP. In contrast, streaming video services, also known as video on demand, have less stringent requirements than VoIP applications.

Other services such as File Transfer Protocol (FTP) and e-mail are relatively non-interactive and drop-insensitive. Though we inferred in this work, the combined impact of the three enhancements, that is, improvements in spectral efficiency, additional spectrum and large number of small base stations, can be expected to provide up to 1000 times more capacity than today. With operational efficiency being one of the key drivers of commercial success for mobile operators today, our work focus on proven process helps practitioners to harness soft 5G migration as shown in Figure 1.2. We have been witnessing an exponential growth in the amount of traffic carried through mobile networks. Moreover, the legacy Internet only treats services equally on a best-effort basis as depicted in Figure 1.1.According to the Cisco visual networking index in Qualcomm et. al, (2013), mobile data traffic has doubled during 2010–2011; extrapolating this trend for the rest of the decade shows that global mobile traffic will increase 1000x from 2010 to 2020. From the perspective of 4G or LTE (*per se* e-Life©), mobile video accounts for more than 50% of global mobile data traffic, which is anticipated to rise to two-thirds by 2018 Kim et. al, (2013), PPP et. al, (2014), Suresh et. al, (2012). Finally, social networking has become important for mobile users, introducing new consumption behavior and a considerable amount of mobile data traffic shown as elevation in upper two curves [ITEA et. al, (2014),The growth rate of mobile data traffic is much higher than the voice counterpart. Global mobile voice traffic was overtaken by mobile data traffic in 2009, and it is forecast that Voice over IP (VoIP) traffic will represent only 0.4% of all mobile data traffic by 2015. In2013, the number of mobile subscriptions reached 6.8 billion, corresponding to a global penetration of 96%.

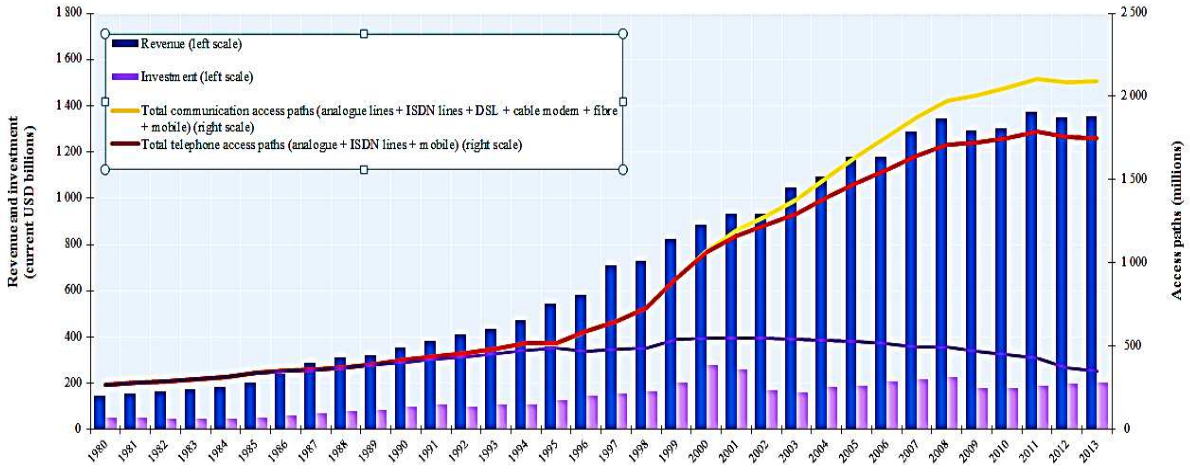

Figure 1.1: Revenue and Investment in US$ for Total Communication Access Paths Over Various Generation 2G, 3G, 4G and the need for 5G Migration. [Qualcomm 2013a, OECD 2015d]

The ever-growing global subscriber rate spurred on by the world population growth will place stringent new demands on potential 5G networks to cater for one billion new customers. Apart from 1000x traffic growth, the increasing number of connected devices imposes another challenge on the future mobile network.

The odoridis et. al, (2013), and Chen et. al, (2012) envisaged the future connected society, everyone and everything will be inter-connected – under the umbrella of Internet on Thing (IoT) – where tens to hundreds of devices will serve every person. For Ghosh et. al, (2010), this upcoming 5G cellular infrastructure and its support for Big Data will enable cities to be smart. Data will be generated everywhere by both people and machines in gigabit per second, and will be analyzed in a real-time fashion to infer useful information, from people's habits and preferences to the traffic condition on the streets, and health monitoring for patients and elderly people. Chung et. al, (2013), and Bakshi et. al, (2013) indicate mobile communications will play a pivotal role in enabling efficient and safe transportation by allowing vehicles to communicate with each other or with a roadside infrastructure to warn or even help the drivers in case of unseen hazards, paving the way towards autonomous self-driving cars. This type of M2M communications requires very stringent latency (less than 1 ms), which imposes further challenges on the future network.

The last few years have witnessed a phenomenal growth in the wireless industry, both in terms of mobile technology and its subscribers. Both the mobile network operators and vendors have felt the importance of efficient networks with equally efficient design i.e.

Efficient Network = Function (An Efficient Design) (1)

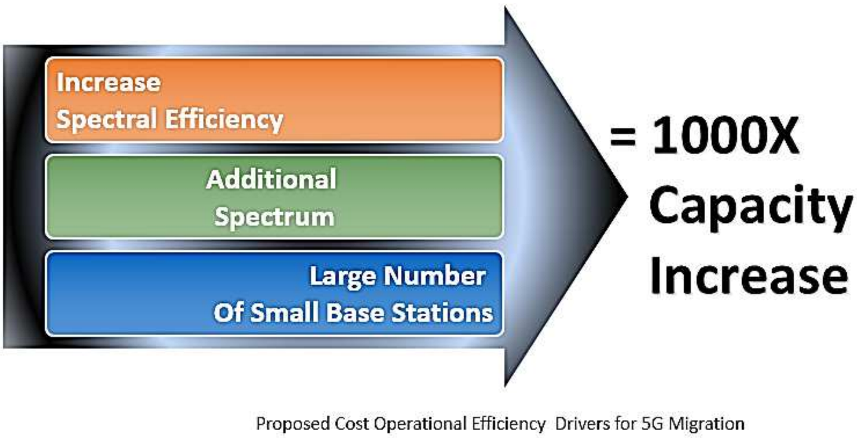

Figure 1.2: A Simplified Overview of Key Indicators to Improve 4G Network Efficiency

The role of Deployment Parameters (DP) in migration is to represent their users, who may be service providers or service utilizer or the procurement vendors, to achieve particular objectives similar to Abangar et. al, (2010), Qualcomm et. al, (2013a). Although there are many attributes concluded in the literature, some attributes are essential for Continuous Deployment Iteration (CDIs) we discuss in this paper. First of all, we define exactly what we mean by the term "deployment parameters" in CDIs. A deployment parameters in CDIs is a software package that can be viewed as a delegate of his1 user to achieve a good performance which usually means a good connectivity as well as Always Available, Always Connected (A2OC)© benefits. To this end, an agent must exhibit the following properties:

- Autonomy: The D3 is capable of making decisions about what actions to take without constantly referring back to his service utilizer or user of Mobile Equipment (ME);

- Adaptivity: The D3 is capable of adjusting himself to environmental conditions based on trading history, *etc.*; Except for these two properties as a must, an DP may possess one or more of the following attributes conditioned on the specific environment where ME is situated;
- Ability to learn: The DP is capable of learning to understand the ME's preferences and behavior, to cope with new situations he may face and to improve his performance over time;

The estimation of a given transformation impact as indicated on MSPs reconfigurability is the most critical part in subscriber A2OC and this paper proposes a strategy to this issue in the next section.

RESOURCE TRANSFORMATION METHODOLOGY

Assuming our 5G resource allocation problem in SCM must be decentralized when considering a practical application migration; the existing 4G deployment can provide several advantages:

- Mobile telecom markets are naturally distributed and MSPs make their own decisions about how to provide subscribed services to their customer either IoT or ME based on tariffs and their own deployed infrastructure;
- Communication is limited to the exchange of deployed infrastructures such as antennas and the process between devices as well as the market mechanism. In particular settings, it can be shown that minimizing the dimensionality of deployed 4G resources required to determine the Pareto optimal allocation;
- Unlike the conventional use of term 'elasticity' in economics, our migration strategy price elasticity is one of the major factors that control the migration dynamics;
- Since subscribed services must back their representations in 5G deployment with exchange offers, some mechanism, in some well-categorized situations, can elicit the information necessary to achieve Pareto and A2OC system optima.

First of all, we formulate a supply chain model as a discrete resource allocation problem with supply/ demand vulnerable parameters, and demonstrate by simulation experiments the applicability of an economic analysis to this framework. Then we prove that the mobile telecom market mechanism can provide several advantages on resource allocation in SCM.

Our proposed business model that includes a B2B e-Marketplace servlets (small SDR applications) with the virtual market that mediates amongst an unspecified range of relevant MSP to demonstrate the applicability of an economic analysis to this framework. Constraint-driven optimization to the 4G deployed applications can be achieved by set of rules for manipulating various representations of a B2B migration methodology. These rules allow exploitation of local or global invariance within the program according to a measured or a speculated performance cost function.

In this section we shall propose the cost elasticity formulation for 4G-to-5G migration (eventually to transform into an e-governess). We have assumed that any typical subscription service re-shaped as a tree-structured representation of a service and that the 4G-to-5G migration are expressible transformed, as pattern-directed rearrangements of service structures, to name a few.

The key characteristics envisaged for a 5G terminal shown above in our transformation space are described below.

- Interoperability: The 5G terminals must be able to access and communicate with different wireless technologies; they will utilize the capabilities of CR to interoperate within a range of technologies. They should be able to recognize their location, position and external radio conditions and determine the best network connectivity.
- Context awareness: The 5G terminals should collect information from the radio environment and adapt their radio parameters accordingly to support energy-efficient connectivity, among other use-cases.
- Learning ability: The 5G devices should be able to communicate with machines and humans alike in an intelligent manner, therefore the terminal must support different machine learning algorithms.

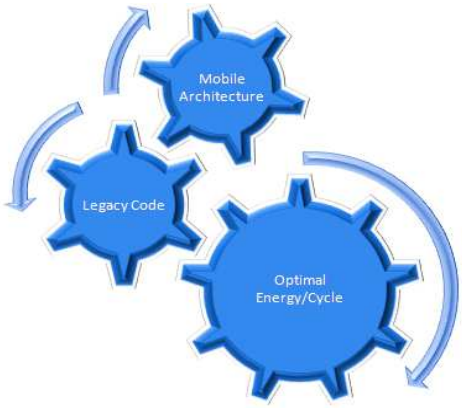

Figure 3.1: An Intra-MSP and Inter-MSP Co-Deployment

PARETO MIGRATIONAL DEPLOYMENT COST MODEL

Our first goal is to simplify the complexity of the 4G-to-5G migration model without sacrificing the accuracy of the results. The second goal is to introduce a methodology that automatically rebinds the 4G existing infrastructure (deployment) with respect to the average migration functional cost, in order to converge to a highly effective design space.

Now given an instance to optimize both air-time and Relative Deployment Cost of SDR application software, the transformation space is very complex.

Finding solution to this is clearly NP-complete; as parameters defined in space ***S*** have a large number of possibilities to achieve an optimal solution for our goal.

We solve this problem by defining 5-tuple transformation rule as shown below:

r = {NoOfCalls, Air-Time, RDC, Call-Stalled, MSPInService}

It allows successive transformation steps to handle number of calls, lower air-time, maintain same level of RDC as obtained in the previous iteration, decrease UE call stalled cache miss and exploit more parallelism among the MSPs.

RESULTS

Typically, we formulate a supply chain model as a discrete resource allocation problem with supply/ demand vulnerable parameters, and demonstrate by simulation experiments the applicability of an economic analysis to this framework. We use Matlab © Optimization Toolbox to prove that the mobile telecom market mechanism can provide several advantages on resource allocation in SCM. As mentioned above, the term ‘resource allocation’ in this paper corresponds to 'subscribed services distribution' seamlessly at all levels of an inter-MSP or intra-MSPs in practical SCM. To perform the robustness, eight test vectors are streamed in our Elasticity Conscious Mobile Service Provider Systems (EConMSP). In order to tax the system robustness, multi-resolution, multi-rate test video are used which are different sampled at different spatial resolution and bit rate. Additional real data data for the framework is obtained from OECD and Qualcomm (2013a).

Figure 4.1 provides number of calls, air-time, inter-MSP, intra-MSPs, non-availability, number of call drops, elasticity factor, and *ConEng_SDR*. There are many other parameters that are obtained directly or indirectly from the profiler are not tabulated for e.g., foreground SDR re-configurability, self healing in individual services to U.E.

We use them to refine our model to high granularity in future. In the transformation cost analyzer block (in term ofcost/Gbits/sec) all these measurements are used to compute the device interoper ability$K$, SDR baseband ς and MSP air-time performance metrics. At the Pareto transformation engine they are further used to decide, whether the current Pareto migration front needs successive transformation to achieve MSP constraints or not.

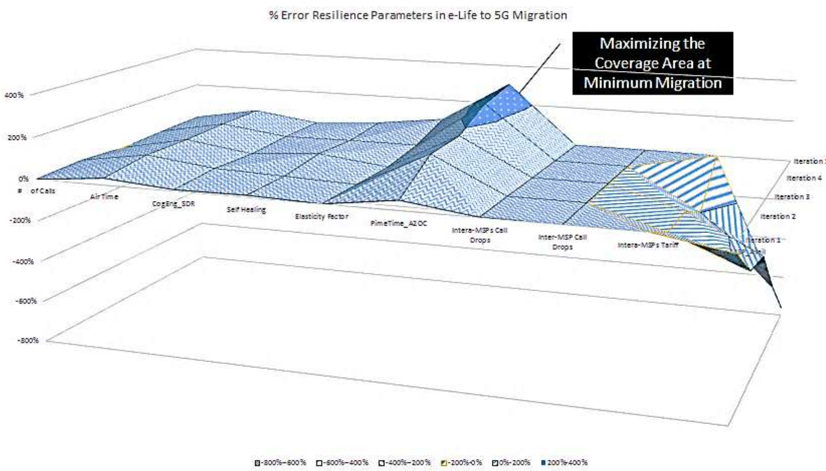

Figure 4.1: Pareto Parametric Optimization Using Our Elasticity Conscious Mobile Service Provider Systems (EConMSP)

There are several cogent observations that can be made from our study to test applications, e.g., transformations are not applied in random order; an attempt to transformation is only made when transformation engine decides controlling parameter (K, ς and MSPs block performance metrics) are within limits and desired performance variables (air-time, # of calls served, MSP availability) are closely approached.

Results for successive transformations applied to the baseline version of a typical video streaming example (as mentioned above). Note that the number of calls are increased in the beginning due to device interoperability but it does increase intra-MSPs non-availability or in term of economy non-utilization. Successive application of transformation based on 5-tuple rules improves subscriber rebinding that improves the elasticity factor and hence the confidence to 4G-5G technology migration success.

Here, we summarize some interesting conclusions from Figure 4.1.

First we have found that the most difficult problems are concerned with transformation ordering and information gathering.

Second, although a transformation may be applicable, it may not win an improvement in the program.

Third, the distraction between MSP-dependent and MSP-independent portions of our transformation methodology is more subtle than it appears. A transformation on a program may be SDR independent, in the usual sense, but the reason for applying it may well depend on the target MSP deployment site.

Fourth, a number of interesting transformations were identified. In particular the concept that a variable use may on occasion be replaced by an expression representing an assertion about the value of the variable is quite powerful.

CONCLUSIONS

We demonstrate, without any major improvements here, any enhancements that we squeeze from the mobile network will not translate back to the end user in terms of Quality of Experience (QoE); the latter a rather more widely adopted term to reflect the actual perceived user quality. Our framework is robust against the non-interactive and drop-insensitive subscriber load for heavy traffic, especially the ever increasing streaming applications. Therefore, it was deemed appropriate to consider heavily taxed video streaming on the 5G Internet to allow us to understand how progress here is also on the same playing field as its mobile counterpart.

In fact, today's technology roadmaps depict different blends of spectrum (Hertz), spectral efficiency (bits per Hertz per cell) and small cells (cells per km2) as a stepping stone towards meeting the 5G challenge. Therefore, our proposed Elasticity Conscious Mobile Service Provider Systems (EConMSP) framework migration towards the 5G era, with advances in small-cell technologies aggregated with supplementary techniques based on advanced antennas (mm Wave and massive MIMO (multiple-input multiple-output) among others) Multiple-Input Multiple-Output – MIMO) and additional spectrum, we can potentially arrive at a candidate solution for 5G mobile networks. Having this in mind, in this paper, our proposed Elasticity Conscious Mobile Service Provider Systems (EConMSP) framework measured small-cell performance based on Long-Term Evolution – Advanced (LTE-A) using multiple antennas to provide a conceptual idea on the limits of densifications. In this paper, we explore the effect of migrating legacy 4G deployments sites from large cells per km^2 factors to the smaller one i.e., cells per km^2 factors for all Mobile Service Operators. We concentrate on MSP re-configurability volatility, including inherent transformation EConMSP algorithm complexity and the developer implementation. Successive transformations are steered by a set of rules, generated in each iteration based on what is device interoperability, device re-configurability, and device time cost elasticity blocking factors as discussed above. The framework robustness is tested for multi-resolution, multi-rate test video are used which are different sampled at different spatial resolution and bit rate. The proposed methodology facilitates the manager to be the strategist. A goal-driven canned set of migration transform may improve the migration cost elasticity significantly.

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