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Impact of Cloud-based Infrastructure on Telecom Managed Services Models

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Abstract. This paper examines how cloud-based infrastruc- ture is impacting classical implementations of telecom Man- aged Services (MS) models with focus on network operations and maintenance (O&M). The migration of legacy network assets to the 'cloud' has altered traditional telecom network configuration. This work explores how cloud-based network infrastructure may alter MS models in the telecom network domain. It is expected that the unique offerings of cloud-based solutions will impact existing MS models and may require redesigning or adjusting operation and maintenance processes and frameworks. As network infrastructure migrates to the cloud, telecom MS delivery models must evolve as well to satisfy new requirements. This paper lays out essential aspects of traditional MS models that may be impacted as a result of cloud-based infrastructure. It further proposes a framework, and conceptual software design for systematically analysing the gaps in current MS models in order to identify requirements for improved MS delivery in the cloud era

Keyword: Index Terms Cloud, Telecoms, Managed Services, O&M.

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1 Introduction

This work methodically lays out the essential aspects of classical or traditional Managed Service (MS) models that may be impacted as cloud-based infrastructures become part of current telecommunication networks. This shift may fundamentally alter how MS models are designed and implemented especially as network assets become increasingly cloud-based and software defined. Managed Services (MS) models are informed by frameworks that guide how managed services providers (MSPs) deliver services to clients e.g. telecommunications (telecoms) operators. One element of this service is Operations and Maintenance (O&M) of the telecom network in- frastructure. The implementation of managed services began with mainly legacy network infrastructure, where most of the infrastructure were owned by the telecom operator.

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As a result MS models were mainly modelled after operator-owned infrastructure formats. This also guided the nature and elements of the contract and service level agreements (SLAs) signed between the MSP and their clients (operators). MS in its basic form involves an MSP managing and maintaining a client's telecom or IT infrastructure on a regular basis for a fee [1]. IT and telecom organisations are often faced with two competing challenges: running their network infrastruc- ture at optimal levels, and the associated increases in cost [2]. The unavoidable need to address the impact of maintaining high performance and controlling cost constitutes a major consideration in operating networks. It is even more challenging in the current highly dynamic technology landscape, with increasing demands on the network infrastructure. However, MS models provide the framework with which managed services contracts and agreements are developed and executed. The scope of the MS considered in this context focuses on the operations and maintenance of network assets or infrastructure.

Another important development in the technology land- scape is the migration of some network assets to cloud- based infrastructure, a critical and essential fabric of cur- rent Information and Communications Technology (ICT) networks. A working definition of cloud service is a service that can be delivered and consumed on demand at any time via any access network and connected devices [3]. Cloud based services can be delivered as Infrastructure- as-a-Service (IaaS) [4], in which case needed network capacity is sourced on an on-demand basis. There are also different offerings possible with cloud-based services at the platform, application and business process levels. Cloud based infrastructure can be owned and managed by operators or implemented as managed services offer- ing. However, due to the unique nature of cloud based infrastructure, the question this work seeks to address is how MS models are being impacted by cloud based infrastructure.

1.1 MS Process & Delivery Models

MS process models can be described as network man- agement models and frameworks that guide operators in improving their business processes and operations [5]. The exact scope and elements of delivered managed services can vary from operator to operator. MS process models may be relied on to guide how network support and operations may be delivered. In the past, telecom operators managed a significant aspect of their IT and telecoms infrastructure. Each telecom operator built and maintained its own legacy network infras- tructure with in-house resources. These legacy network infrastructure incurred significant investments in terms of both capital and operating expenditures. Operators had to struggle with the massive capex needed to build and operate networks especially in developing countries where infrastructure is poor. However, the introduction of managed services and its underlying models provided a means for telecom operators to address significant challenges common with the pre-MS era. By adopting the newly introduced managed services delivery models the operators began to evaluate which model suited best. Essentially MS and supporting delivery models redefined how network management and maintenance was carried out, and provided a means of addressing the performance versus cost dichotomy. Operators minimised the impact of cost by adopting some variant of managed services that suited its strategic direction. By adopting managed services, organisations retained only core activities while outsourcing other aspects of its business/operations. This strategy saved up to 20% on network operating cost and helped organisations focus on core missions [6]. In the aspect of performance, MS was also seen as a positive factor as the MSPs provided the much needed expertise at a lower cost. The MS processes and delivery models provided guidance on how MS could be implemented effectively. Generally, managed services can be delivered under the following delivery models [7];

- Full MS Commitment with Single Interface: The operator transfers all or a sizeable chuck of its operations to a single MSP. The MSP usually engages subcontractors or local partners to deliver the MS project. The MSP/MS is governed by strict service level agreements (SLAs) which is further broken down to operational level agreements (OLAs) for governing the local partners [7].

- Partial MS - High-Level Activities: The operator en- gages a global vendor with strong technology capacity to lead the MS delivery project [7].

- Partial MS - Low-Level Activities: In this model the operator transfers some parts of the field maintenance to a local partner with speciality for that particular area [7].

1.2 eTOM and ITIL Frameworks

In order to develop and implement effective MS models, it was essential to use generic business process frameworks or models to identify and establish significant business and operational activities [8] that will be critical to MS delivery regardless of customer or service scenario. It is therefore essential to outline the main reference frame- works that have been used over the years to guide business and operation activities with the telecommunications and IT domains. These standards and frameworks known as enhanced Telecommunication Operations Map (eTOM) and Information Technology Infrastructure Library (ITIL) provide guidance on how MS operations can be imple- mented in an ICT environment. There are clear differences between eTOM and ITIL; while eTOM is a standard, ITIL is not, but provides a comprehensive guidance for IT Service Management [9]. In its basic form eTOM is designed with focus on service delivery to the external customer in the telecommunications environment. Op- erators and service providers in the telecoms domain rely on eTOM to categorise the process elements and business activities that are essential to delivering end-to- end service (figure 1, shows the highest conceptual view of the eTOM framework).

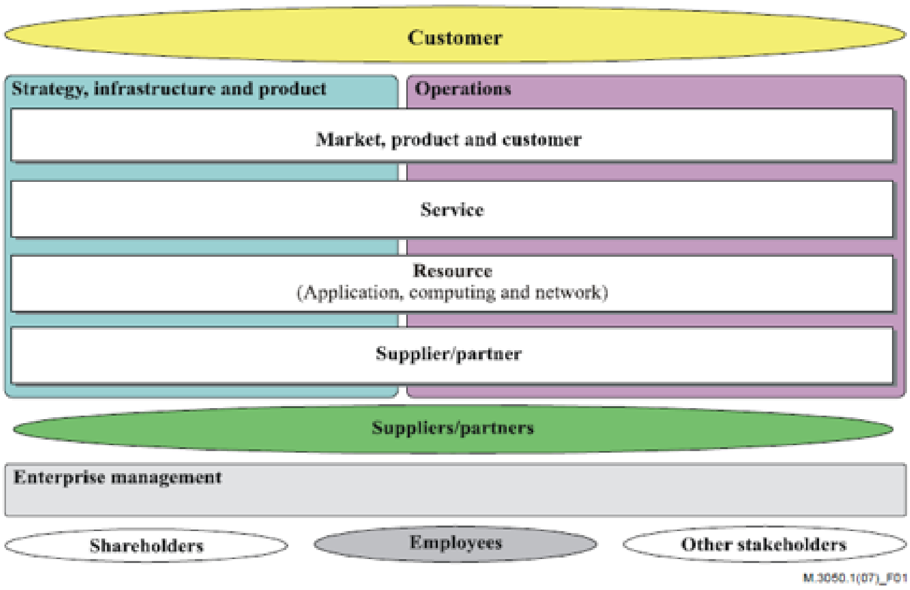

Figure 1 eTOM Business Process Framework – Level 0 processes [8]

ITIL on the other hand is most commonly used in managing services to mainly IT specific business or operational environments. ITIL has gone through several iterations over the years and was currently updated to version 4 (ITIL 4) (see figure 2) from version 3 which was introduced almost 10 years ago [10]. This latest version focuses on the main principles and concepts of service management rather than the ITIL processes [11]. The introduction of ITIL 4 was necessary to address the complexities and challenges of the digital transformation with the IT industry driven by emerging technologies like Cloud, Big Data, AI, automation and IoT [12]. The impact of cloud on IT service management was addressed in a white paper from AXLOS. The paper insisted that the overall objective of IT service management which is to create quality services and products fit for purpose remains unchanged. However, the article noted that the proliferation of cloud-based services will impact the IT industry by disrupting the business model and service transition and operation processes of traditional IT service providers [12].

Figure 2 ITIL version 4 [11]

However, both the eTOM and ITIL frameworks can be seen to have overlaps in scope; and in some aspects the differences become very blurred. There has been efforts to integrate both frameworks by exploring how both can inter-work (see figure 3). In the current technology landscape, where IT and Telecoms have converged this distinction may have completely disappeared and under- pins the need for a unified framework; a position this work advocates. However, eTOM and ITIL provide the basis on which many MS delivery models are structured and implemented. Each framework provides guidance on how to fulfil customer requirements and business needs. For instance eTOM defines end-to-end vertical processes that detail customer operational processes like service Fulfilment, Assurance and Billing (FAB). It also covers Operations Support and Readiness (OSR), which is an enabler for FAB. In implementing MS projects, O&M delivery are modelled using OSR processes.

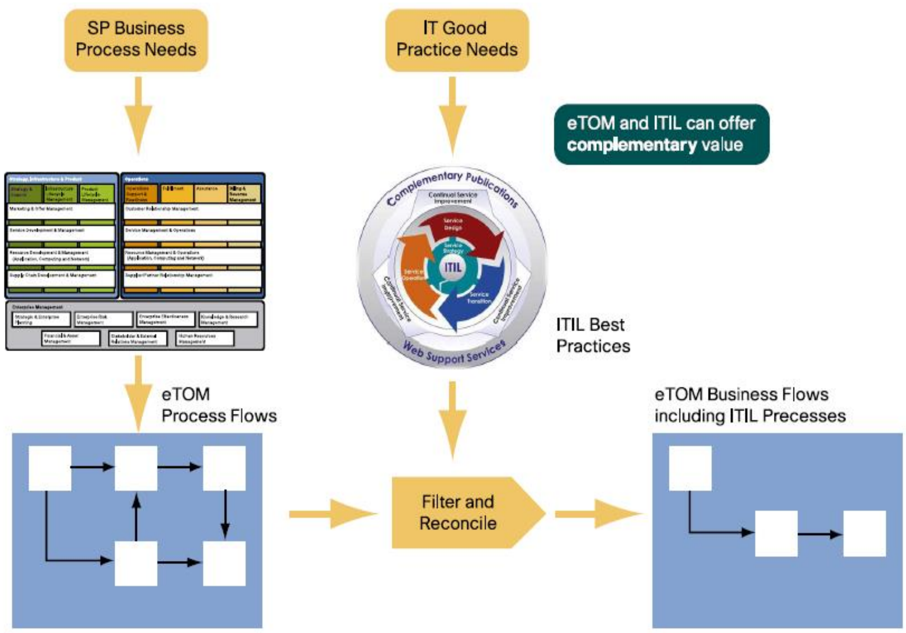

Figure 3 eTOM and ITIL Framework Convergence [9]

1.3 Overview of Cloud based Infrastructure

Cloud infrastructure has become a critical part of our current ICT technology and network landscape. Initially cloud services and infrastructure was viewed as trending technology, however, it has steadily grown to become a foundational element of our current communications infrastructure. Cloud infrastructure can be generally cat- egorised into public and privately owned cloud infrastruc- ture. This categorisation may also provide insight into how cloud based infrastructure is changing MS delivery models. In other words, understanding how privately or publicly owned cloud infrastructure is impacting MS models may be helpful in MS delivery for cloud-based environments. Cloud infrastructure can offer diverse range of generic services in the following modes or combination of modes [13];

- Software as a Service (SaaS): Involves using the cloud provider's applications and softwares running on the cloud infrastructure [13].

- Infrastructure as a Service (IaaS): This covers ser- vices where the user can provision computing re- sources like processing power, storage, networks etc [13].

- Platform as a Service (PaaS): Provides users like soft- ware developers the capability to create and deploy software products without owning any infrastructure e.g. Microsoft Azure [13].

- Cloud services and infrastructure enable all sizes of users to scale operations very easily and flexibly; this is particularly useful for enterprise customers.

2 MS and Cloud Concepts - Trends and Evolution

In this section the MS and Cloud concepts will be reviewed and attempts made to aggregate the trends and evolution of both concepts as critical aspects of network infrastructure. The section will further review insights, consensus or contradictions among the extant literature within the MS domain especially by industry stakeholders and experts in the area. MS implementations can be dynamic and uniquely applied to each case as contracts and agreements may vary from client to client, however, the central idea is to meet operators strategic targets.

2.1 Telecom Managed Services (MS)

Lurin & Legrand (2014) [7], noted that classical telecommunications businesses in the past operated a model where these operators had full responsibility for network operations and also owned both pas- sive and active network assets. The paper further established that one of the main drivers of MS in fixed networks was the quest of international telecom operators to set up multi-country backbone networks between 1997 and 2002. The lack of personnel in those countries precipitated the need to contract telecom vendors like Alcatel, Ericsson and Siemens to support these big international telecom operators. However, Venkatesh & Singhal (2017) [14], viewed MS as a misrepresented concept; in the paper the writers suggested that MS should not be tied to the technology space alone, it can be extended to non- technology domains. The authors insist that there are distinctions between MS, outsourced services, business process outsourcing (BPO) and managed business services. Ramirez J [15], argues that the traditional motivation for MS has shifted as the focus of telecom operators is now service-centric and no longer network-centric. In the network-centric era the adoption of MS was to achieve mainly cost saving and bottom line considerations, however, service- centric MS is customer driven. Next-generation MS will achieve business transformation through service- centric methods i.e. providing the customer what they need at all times. However, Cisco in its white paper insists that the motivation of MS remains to balance the competing forces of optimal operating levels and high costs [2]. Taga et al [16], viewed MS from the perspective of a product which telecom operators should sell. Their position is evolutionary as it takes MS from the platform of an enabler to a potential growth commodity. The paper reinforces its position by describing the network assets of operators as MS offerings that can be sold. Six areas were identified that telecom operators can convert into MS offerings; voice & data, enterprise networks, security, equipment, data center & cloud and applications. Ericsson in its analysis of MS evolution unifies competing views on the core motivation for MS by arguing that traditional MS offerings which focused on cost-efficiencies is still relevant [6]. In the paper Ericsson maintained that achieving cost-efficiencies can be viewed as a phase in the evolution of MS; while the new phase is currently a combination of cost- efficiencies and structural-efficiencies that creates value and sustainable business differentiation. The paper further defined experience centric MS models as those that focus on customer expectations and demands providing a means to align service delivery to customer requirements.

2.2 Cloud based Services - Trend Analysis

The emergence of the Cloud has had significant impact in the way networks are deployed and im- plemented. Cloud computing can be seen as an evolution of the old Application Service Provider (ASP) model (developed around the 2000s) which in itself is an evolution of the Internet Service Provider (ISP) model [3]. Schubert et al [17], viewed the cloud as a global phenomenon with huge multi-disciplinary potentials and will necessitate collaboration between different areas. In similar vein Biggelaar et al [4], identified telecom operators as both providers and consumers of cloud services and therefore at the middle of the cloud's disruptive impact. In the paper a cloud maturity model was proposed to aid the communications service providers (CSPs) to map their path to cloud maturity. In a similar argument PWC advised that since cloud is destined to become ubiquitous, the telcos (telecom operators) should develop a new business model for the cloud [18]. It highlighted the reluctance of the telcos to embrace the cloud concept in the early stages of its devel- opment. However, it became apparent that cloud based solutions will dominate the communications ecosystem. FluentStream Technologies, argued that telecommunications technologies was primarily based on older paradigms compared to web technologies and informs why cloud based technologies have had signif- icant impact on telecom networks [19]. In essence it was easier for web based technologies to adapt to the cloud compared to legacy telecom networks. It iden- tified lower costs, faster and flexible deployments and increased speed to market as some of the advantages of deploying cloud services. Gabrielsson et al [20], maintains that the cloud has triggered and enabled new and changing business models, however, access networks have a vital role in the implementation of cloud services. In essence the paper argues that telecom operators are naturally best positioned to dominate and control the access transport networks. However, the design of 5G is cloud-native and will mimimise dependencies on access transport networks by localising services to where it is needed. MS and Cloud based services came into the tech- nology landscape at different times, however, both concepts are still relevant in network infrastructure implementations. MS delivery is expected to be impacted by the dominance of cloud services. Re- gardless MS and delivery models are still relevant and maintains technical and business relevance. Almost all of the reviewed literature maintained consensus on the impact and profound dominance of cloud based services; some authors differed on the approach that telecom operators should take in engaging cloud based infrastructure.

2.3 Cloud Managed Services

At this point in the work it is important to distinguish the concept of Cloud Managed Services (CMS) from the general context of managed services addressed so far. In the literature CMS is becoming increasingly popular and applied in different cloud services specific scenarios. CMS can be described as managed services exclusively deployed within the cloud ecosystem. It is essentially the outsourcing of daily IT management tasks like network operations for cloud infrastructure [21], [22]. CMS specifically addresses the means and capacity to effectively manage and maintain cloud environments and may include activities like monitor- ing, performance testing, security, application stacks and much more [22]. However, migration to the cloud and choosing the right Cloud managed services provider (CMSP) can be a challenge. For instance, Deloitte [23] in its technical paper identifies one of the major challenges with CMS is finding CSMPs that can offer critical IT management services be- yond just providing the physical IT infrastructure. They addressed this problem by developing models that can support the customer to develop turnkey solutions that can assure management of cloud-based infrastructures with critical business applications. In its research paper, Predatar found that massive cloud adoption is changing the current IT landscape and demanding innovations in network management [24] . This cloud adoption is also driving MS and significantly opening up new opportunities for MSP diversification into cloud specific offerings giving rise to Cloud MSP models. However, CenturyLink in its publication advices that organisations should sufficiently understand the services required before choosing CSPs [25]. This will in turn help avoid developing ‘Shadow IT’ that will lead to increased costs and security concerns. Therefore, CMSPs must be chosen with this issue in mind to achieve consider- able dividends for the operator. Some of the benefits of adopting Cloud managed services are summarised below;

- Cost Savings.
- Flexible and Scalable Solutions.
- High Availability, Reliability and Performance. – Disaster Recovery and Business Continuity.
- Dedicated and Expert Support 24/7.

3 Analysing the impact of cloud infrastructure on MS models

The concepts of MS and Cloud infrastructure has been introduced and some basic definitions, trends and evolutionary trajectory highlighted. However, the main objective of this paper is to identify and analyse the impact of cloud infrastructure on telecom MS models. This analysis is important in order to guide any recommendations for changing or adjusting cur- rent MS models. This work will examine the impact of Cloud infrastructure on MS models vis-a-vis the main pillars on which successful MS operations are hinged, which are people, processes and tools (see figure 4). These concepts will be examined further under the following themes;

- MS Delivery Organisation (People)
- MS Delivery Processes (Processes)
- MS Delivery Platform (Tools)

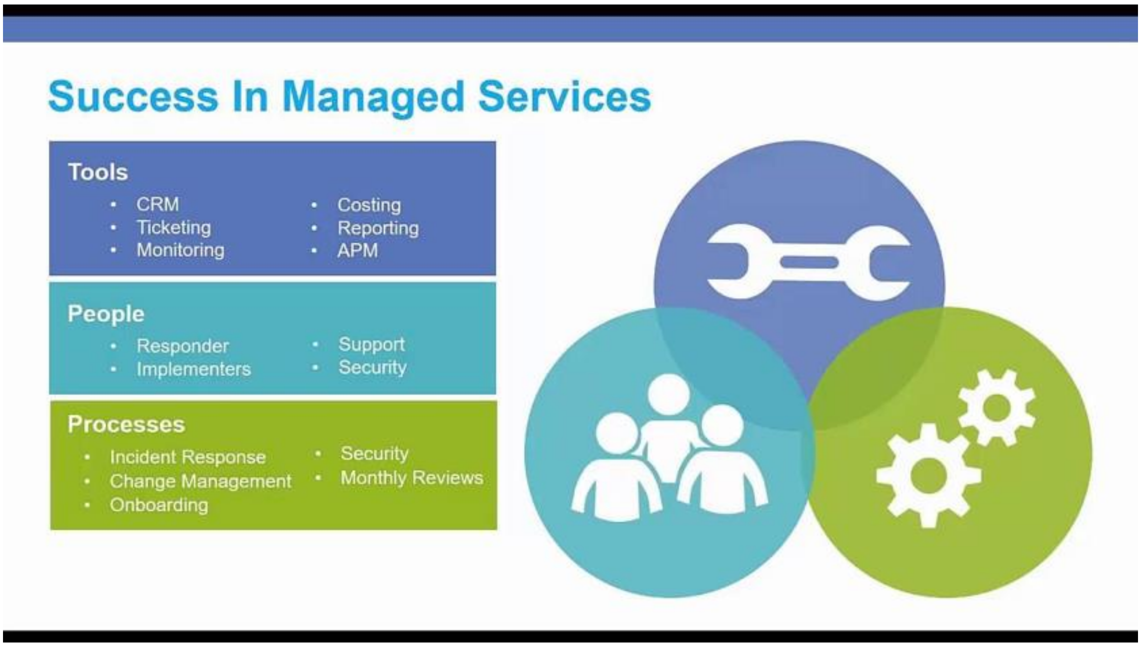

Figure 4 MS Main Pillars [26]

3.1 MS Delivery Organisation

The delivery organisation is a key component of any MS Model and is directly concerned with identifying the right roles and people for successful delivery of any MS project. It ensures that the right people are located in the right place, however, in some MS implementations the delivery organisation are made up of resources transferred to the MSP from the customer. In such cases the transfer of resources can be a huge part of the MS contract and can fundamentally change the structure of an MSP's delivery organisation. These types of people transfer scenarios are common in situations where operators are outsourcing their O&M functions. However, in this cloud era the MS delivery organisation may assume a much leaner and almost decentralised formation. The use of cloud infrastructure means that operators are able to host different network assets with cloud vendors without much interface with the main MS delivery organisation. The delivery organi- sation in these instances are not 'transparent' to the operator as SLA fulfilment and management takes centre stage. The MSP must then develop models to build delivery organisations that are able to support O&M delivery. For instance, 5G networks will depend on the Cloud and virtualisation technologies which may result in MSPs building new teams for network O&M [27]. Operators in this cloud-centric era will progressively interact less with delivery structures but will adopt MS models that assure agreed service levels. This may fundamentally change existing O&M frameworks and processes of the delivery organisation and their interaction with operators. In the cloud based era it is possible that delivery organisations will become more software driven with less people input. This impact may change how MS delivery organisations are built and deployed in the cloud infrastructure dominated era.

3.2 MS Delivery Processes

MS processes can be perceived as the vehicle that drives MS in whatever configuration it is delivered. The eTOM framework actually provide users with the foundation to develop enterprise-wide processes to meet desired delivery objectives. However, these processes are largely dependent on prevailing opera- tional circumstances; hence they are designed to be generic and easily adaptable to different MS delivery scenarios. In traditional MS offerings, processes are developed to address key aspects of the interaction between the service provider and the customer, with a view to providing Fulfilment and Assurance. In cloud-based settings processes as originally intended may be impacted to some considerable extent. For instance, SLA formulations will assume a more complex configuration depending on how the cloud services are offered. Normally MS processes detail how network monitoring, fault management, change management etc are carried out. However, current MS models from the operator perspective will focus on defining solid SLAs with less scrutiny on how these processes are implemented. The cloud era provides the operator with cloud redundancy, which reduces the impact of MSP process issues. The operator will take the advantage of infrastructure-as-a-service (IaaS) offerings to develop MS models that insulates MSP process challenges. This may also streamline the process requirements for network operating centres (NOC) that traditionally aggregated activities c[[]en- tral to MS delivery. In this cloud-based infrastructure era the convergence of IT and telecoms means that eTOM and ITIL processes are finally going to be integrated. As many telecom operators are embracing the cloud, the difference between telecom network focused MSPs like Huawei and Ericsson, and IT MSPs like IBM and HP may become integrated at least at the process level. 5G networks are expected to be cloud-native, therefore the MS models that will support operators must also evolve to accommodate stringent SLAs that capabilities like network function virtualisation (NFS), network slicing and software de- fined networking (SDN) will demand, from a process perspective.

3.3 MS Delivery Platforms

Finally another area of impact is the software tools or platforms that MS models will be implemented on. In traditional MS models, the emphasis was to use platforms that integrated processes and enabled end-to-end execution of relevant work-flows. In some advanced tools, network monitoring, fault escalation, fault ticketing, remote alarm monitoring and other relevant delivery processes are automated to improve SLA fulfilment. However, in the current cloud era, the operators will demand platforms or tools that will im- prove end-user satisfaction and adapt to dynamic net- work requirements. The service-centric paradigm will place demands on the MSPs to meet availability and reliability levels in line with growing end-user service demands. The automation of service platforms will aggressively demand artificial intelligence (AI) driven solutions that will differentiate service offerings and meet stringent SLAs. MSP NOCs in the cloud era will be nothing short of AI machines that can provision service and anticipate traffic bottlenecks before they occur. For instance, Ericsson currently has a new Artificial Intelligence (AI)-based managed services offering that directly and proactively addresses MS complexity supporting 5G and IoT networks [28]. Telecom operators will demand MS delivery tools or platforms that can cope with the anticipated revolution of 5G cloud-native architecture.

4 Recommendations for mitigating cloud impact on MS models

The impact of cloud infrastructure on current telecom MS models has been highlighted; in this section some recommendations for addressing this impact will be outlined. It is important for new models to take into account the complex and dynamic nature of Cloud based services. However, the mitigating recommendations address the O&M aspects of MS implementation specifically. The mitigation recom- mendations are addressed below and capture areas where changes are needed for better MS delivery results;

4.1 O&M Process update is Needed

Traditional O&M processes like fault management, change management, problem management and so on are already covered in ITIL and eTOM frameworks in very generic formats. Over the years, these processes have been the bedrock of O&M implementations guiding operators and MSPs on how to deliver MS successfully. Going forward some of these processes will gradually become integrated or redesigned as technology capabilities and network functions be- come virtualised and automated. However, some aspects of the telecom infrastructure will remain aligned to traditional MS processes for the foreseeable future. For example, in networks where legacy 2G and 3G networks are still supported, traditional O&M processes will remain relevant; though MSPs now own the maintenance functions as most operators have mature MS contracts in place. In this cloud based era, new processes may be required to address the new paradigm. This will involve a careful review of exist- ing eTOM and ITIL process recommendations. The new 5G networks will introduce a fully cloud-native network which will require the operators updating MS contracts and SLA definitions to accommodate new requirements in the network value chain. The MS processes will have to address how the operators interact with cloud vendors; and how cloud vendors execute MS to meet agreed SLAs.

4.2 Software Tools and Platforms as Enablers

Software tools and platforms will fundamentally change how telecom MS delivery is carried out in the cloud era. As software capabilities and tools improve, the processes and people aspect of the MS triad will be impacted. The software tools will become more 'intelligent' requiring less human inter- vention with capabilities to refine and update process flows. The cloud based network infrastructure will be differentiated based on this and will be able to deploy robust algorithms to improve O&M delivery across the network. This will have huge implications on how MS delivery is implemented in the future. MSPs will invest more in these software capabilities to improve efficiencies, delivering cutting edge MS services with leaner processes and teams. The MS models will have to accommodate these changes and may require some fundamental changes in format. This work however, focuses on the changes that will be made to telecom network O&M models which continue to reside with the MSPs. The operators will be keen to work with MSPs that are conscious of these changes and adjusting their MS frameworks to address these impacts. Unlike the 2G and 3G networks, future networks like 5G will disrupt the MS value chain in significant ways e.g. entirely new verticals are expected that will demand different SLAs. The operators have to accommodate these new entrants and ensure that MSPs are equally aligned to meet service demands. In this new era, software tools and platforms will become enablers in meeting stringent service requirements over a spectrum of use cases. The software tools will provide capabilities which will improve service delivery and may ultimately dominate the MS triad of people, process and tools (in this era, tools will be king).

5 Proposed MS Model Update via Gap Analysis Approach

In the light of the above analysis, this work will pro- pose a gap analysis approach to identify requirements needed to improve telecom MS models in the cloud based era. The intuitive approach will be to respond to emerging technologies or the perceived impact of digital transformation in the telecom and IT domains. For instance, the adoption of 5G will fundamentally change how telecom networks are deployed and main- tained. Data centres as the heart of the cloud-based infrastructure will have its O&M processes signifi- cantly upgraded to meet current demands. MSPs managing data centres will experience significant pressure to upgrade delivery processes and tools to meet the reliability and availability that operators will demand in contracts and SLAs. However, from a high level perspective, traditional models of MS may be inadequate to address the needs of maintaining future networks. It is important to run a systematic gap analysis on current implementations and identify which processes and roles will be redundant in the cloud era. The output from the gap analysis process will be used to guide revisions to existing MS models mitigating anticipated changes in the MS value chain. The flowchart in figure 5 outlines the the gap analysis approach proposed in this work.

In order for the gap analysis to be effective it must be approached methodically as outlined in the flow chart. The analysis is designed to address the three aspects of the MS triad i.e. processes, people and tools, following a specific order. The order in which the gap analysis is implemented is important and may significantly improve the effectiveness of the gap analysis process. There are four key layers or phases that has to be implemented in the order outlined in the flowchart and described further below;

- Process layer analysis (Phase 1)

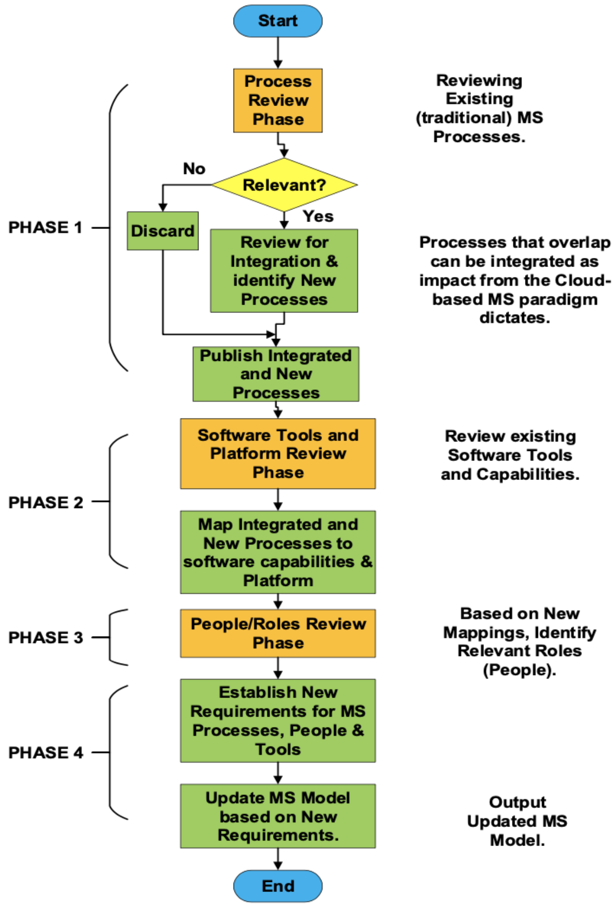

Figure 5 Proposed MS Gap Analysis Process

- Software/Tool layer analysis (Phase 2)
- People/Role layer analysis (Phase 3)
- Requirements Consolidation layer (Phase 4)

5.1 Process layer analysis - Phase 1

The gap analysis should be able to guide system- atic layer by layer review of current frameworks to identify any existing gaps. From the flowchart, it is recommended that the gap analysis start from reviewing existing MS processes and their relevance in a cloud based context. This analysis is important as new technologies and capabilities may render some processes obsolete or inadequate. For instance, software defined networking (SDN) may alter the way Change or Configuration Management processes are executed, as SDN allows for dynamic programma- bility e.g. reconfiguring switches or routers on the network [29]. So it is important to review existing processes and determine which should be discarded, integrated or created. The processes gap analysis is critical and as recommended should be carried out in phase 1. Clarifying what processes are relevant in a generic sense will be quite helpful and ensure that MS frameworks are fit for purpose. It is also expected that processes will have to vary from project to project or made to fit the application scenario. The era of rigid process implementation will become increasingly problematic as the deployed cloud ser- vices will vary significantly from operator to operator. During the process gap analysis, it is important to highlight the objectives of each process regime and compare with current requirements. The value addition of any process to the overall MS delivery objective should be the ultimate selection criteria. Processes should add value to the service value chain and any process that does not meet this criterion may be redundant. In the current cloud-based ecosystem, processes will be streamlined and in some instances embedded within software architecture. For instance, network slicing will introduce multi-tier QoS and KPI regime which can only be managed effectively at the software level. The processes for supporting O&M for such multi-tiered networks will require flexibility enabled by software e.g. AI machines. In any case, the gap analysis of the process layer will provide clarity on what processes are required to meet stringent operational requirements for cloud-based networks.

5.2 Software/Tool layer analysis - Phase 2

The process review layer is followed by a software tools review layer known as phase 2, which essentially establishes the capabilities of existing software tools and platforms. This phase is critical as it defines how effectively published processes can be implemented on the software platform. It is expected that cloud networks will benefit from advancements in software development and intelligence which will further im- prove process implementation. As mentioned earlier the development and advancements in software tools will significantly alter how MS models are imple- mented. The gap analysis of the tools layer basically ensures that the power of machine learning and AI are harnessed for efficient and smart operation of telecom networks. The conventional thinking was to define processes and work flows and then use software tools to automate such work flows. This approach to process flow automation may continue to be used with low level tasks or older networks. In the cloud-based era software platforms will be equipped to make high level decisions at lightening speed in order to improve efficiency and reliability of networks. Data analytics and AI machines will be expected to drive this layer and ensure that dependence on rigid work flows and human input is reduced significantly. For instance, Ericsson AI-based operations engine simplifies MS operating model by using AI, automation and analytics to address anticipated network complexities of 5G and IoT networks [28]. Therefore, the software platform layer gap analysis will map current software capabilities to the requirements of MS models. This may lead to process activities and execution becoming more simplified and easily updated. It may also provide proactive capabilities which will reduce network fail- ures and improve availability and reliability. From a KPI management point of view, improved software capabilities and application will support better KPI monitoring and management for both the operator and MSP/CMSP. It is the considered view of the authors that in the cloud-based era software tools and platforms will be central and key element in the MS triad of processes, people and tools.

5.3 People/Role layer analysis - Phase 3

The people or role review phase will define relevant roles based on outputs of the process and software tools layer reviews. As expected future MS delivery organisations will be leaner due to software ad- vancements delivering improvements with less human input. Roles originally manned by human operators may be taken over by automated and intelligent systems. For instance, network operation centres (NOCs), will increasingly become automated with advanced software tools that eliminate the need for human operators as originally used in MS operations. New roles may be developed but ultimately the new MS delivery organisations will be leaner and highly efficient as network intelligence and MS software platforms become more advanced. The people or role layer gap analysis will provide clarity on the human requirements dimension of the problem. It is generally agreed that AI and current advancements in machine learning will lead to significant human job losses. This fact will be made apparent if the processes require minimal human input for execution due to increasing software "intelligence". Following the sequence or order stipulated in the flow chart is deliberate and ensures that redundant roles are eliminated. This phenomenon is already in progress, for instance, modern NOCs run with minimum number of first line engineers as network tools are capable of monitoring and dispatching trouble tickets to field engineers; this trend will only continue into the cloud-based in- frastructure era. However, the advent of cloud-based services will also require upskilling engineers or new specialist skill sets though in minimal numbers. This underscores the need for a deliberate gap analysis review to identify what human roles are relevant or redundant . The net impact however, will tilt towards a learner MS organisation reflecting the dominance of software tools & platforms in this era.

5.4 Requirements Consolidation layer - Phase 4

Finally the requirements consolidation layer involves the aggregation of all the findings from phase 1 to 3. This consolidation of requirements will guide how MS models are updated in order to minimise the impact of the Cloud. Such requirements consolidation may be run on a single project by an organisation or employed as a tool for generalised framework reviews. This gap analysis flow process may be useful in updating the eTOM or ITIL frameworks to address O&M and overall business process requirements for Cloud-native telecom networks. Already ITIL 4, as attempted to address this impact, however, having a simple gap analysis tool or mechanism will help improve cloud impact analysis and mitigation. Fur- thermore ITIL 4, did not focus on processes but end user service delivery in order to improve the service value chain. In making the transition from traditional MS models to cloud-based services it is important to run a detailed gap analysis at least for the sake of improving technical and business decision making. The requirements consolidation layer which is identified as phase 4 in the gap analysis flow chart is key to translating phases 1 to 3 into value adding data. It is important to iterate through phases 1 to 3 sufficiently before executing phase 4. However, this gap analysis tool may be used at the beginning of a project or indeed at any time in the project life cycle. It can also serve as a service procurement tool to help an organisation articulate requirements for engaging an MSP/CMSP.

5.5 Conceptual Gap Analysis Algorithm

The gap analysis flow chart discussed above can be developed further into a software based solution. This conceptual software platform can support the implementation of the 4 phase gap analysis recom- mendation. In this era of machine learning and AI- based approaches to problem solving, a software that can implement the recommended 4 phase gap analysis process can be a game changer. The algorithm (see algorithm 1) describes the input and output of such a software. However, the scope of this paper does not cover the actual development and implementation of the algorithm in software.

This conceptual software is designed to take in the current processes of an organisation and output a recommendation for requirements to achieve lean and effective MS model. In this era of AI driven software solutions, it may be useful exploring this approach. Gap analysis using traditional templates may not yield the level of efficiency expected. Writing a suitable code to support the gap analysis process and integrating such a software to an operational system can revolutionise how organisations may mitigate the impact of disruptive technologies like the cloud. In future this work will explore the prospect of devel- oping this conceptual gap analysis algorithm design into a portable gap analysis software that can be used to automate such tasks. However, such software will increasing improve in efficiency as its database grows with massive data infusion and updates from different sources for training. AI-based solutions may provide

Algorithm 1 MS Gap Analysis Algorithm

```
Input: Existing Processes
Phase 1 Analysis Initiated ◂ Gap Criterion Defined
Output: Process overlaps and Redundancies
Phase 2 Analysis Triggered
Output: Task Automation Feasibility & Recommendations
Phase 3 Analysis Triggered ◂ Human Roles Analysis
 if Task Automation = True then ◂ No Human Needed
Replace human operator with Automation
else if Task Automation = False then ◂ Human Needed
 Identify Human Role
 Output: Recommended Human Roles
 end if
 Phase 4 - Consolidation Phase ◂ Aggregating Phase
Output: Gap Analysis Aggregated Data for Decision Making
```

capabilities for achieving this, and will ultimately improve decision making at different levels of the MS value chain in the cloud era.

5.6 Conclusions

The work has identified and analysed how Cloud- based infrastructure could impact current telecom MS models especially for O&M delivery. As network capabilities and cloud technologies become advanced, telecom networks may need new sets of requirements for MS models to deliver MS services to operators. Understanding how Cloud-based infrastructure will impact MS models may help improve MS service de- livery through improved processes, advanced software capabilities and leaner MS delivery organisations. 5G networks will challenge current implementations of MS O&M models as a fully cloud-native network. Therefore, reviewing gaps and identifying new re- quirements for improving MS models in the cloud era is very critical. This work proposes a generic gap analysis framework that can guide reviewing and updating MS models to identify gaps and establish new requirements suitable for improving O&M for the Cloud era. It is expected that MS processes will become more integrated with advanced software tools & platforms, and less human operators. It is also possible to address the problem by developing a gap analysis software based on conceptual design discussed. The Cloud era will significantly alter MS models as operators introduce complex SLA regimes to address different use cases and a wide spectrum of customers with varying quality of service (QoS) needs. MSPs must begin to address gaps in existing MS models in order to meet the demands of telecom networks of the cloud era.

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