Tomorrow’s Agile Operations

A blueprint to “Think Differently”

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In cooperation with

NOKIA

Appledore
RESEARCH
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EXECUTIVE SUMMARY

Our industry is at a critical decision point, with opportunities in fields as diverse as the industrial internet vs. mobile consumer entertaining, and cloud technology offering radically new levels of personalization and economics. It is incumbent on us to leverage these opportunities to their fullest.

In this paper we lay out a vision for the future Communication Service Provider (CSP) operational environment. We look at the tightly intertwined technical and business transformation that faces our industry; a transformation with tremendous opportunity but also deep challenges that need us to rethink basic assumptions about our industry. Specifically, the industry must prepare to operate in digital time, in an agile, cloud-native environment and understand what that means for each and every aspect of our business and operations.

Cloud technology is changing both our infrastructure and our customers’ operations. Everything from virtual operators, to the industrial internet, to ad-hoc industry collaborations are creating new opportunity, but also demanding new business relationships – ones that are agile, dynamic and deliver higher value for money. At the same time cloud technology is making this transformation possible and profitable, but only if we rise to the challenge. We cannot overstate the following: this is not a technology change, it is a business model and operational change, enabled by technology and supported by technology. It will impact people, organizational structures and business processes - and this is GOOD.

Specifically, we will present the opportunities, challenges and best practices that will allow service providers to make 100:1 improvements in many cost and agility metrics, to lower the costs of systems integration and maintenance of management systems, and to make agile innovation realistic. We have endeavored to boil this complex set of challenges down to a set of simple best practice themes that show up again and again. Some are deeply technical, others demand changes in people and how we view our roles and our value in the business.

While the opportunity is big, and the changes are extensive, we also caution that “big bang” transformations are both risky and un-necessary. We prefer to let evolution happen, with real business challenges and opportunities driving change. This gives us real measures of success and failure along the way. But incremental does not mean random: we advocate a shared end-goal and the philosophy of “thinking globally, while acting locally” – doing our part in a march to a shared destination, the Telco Cloud.

1 Source: Appledore Research, “The Economics of Virtualized Networks”. And “Control Theory Applied to Closed Loop Automation”. 
In the end, a thorough understanding of these best practices simplifies our journey. It shows how various operations functions fit together; it reduces the frequency of “re-invention”, and it allows us to re-use both software and experience. In the interest of brevity, consider this document as a “jumping off” point for more detailed examinations of the technologies and operations processes discussed.

**INTRODUCTION – A REVOLUTION IS UPON US**

*“This time it’s different”*

A dangerous phrase, often made, rarely true. We believe that telecom operators are in a seminal period of change that is more dramatic than any previous disruptions. Several technologies, including cloud, SDN, and AI, are now coming together in a “perfect storm”, and we must choose whether to embrace them or merely implement them. Cloud, with AI and SDN, can transform the very fundamentals of our business – dramatically driving costs down, agility up and addressable market up. Yet making the most of this opportunity demands that we abandon some long-held business assumptions and operational ways of working – and turn our back on decades of experience and tradition that has served us well – but is now holding us back. Fundamentally we must envision a new business and operational model, rather than adopting new technology within an existing business and operational model. For business model change to occur, we must re-evaluate organizations, structures, business processes and long-held assumptions. We must not fall victim to the short-sighted view of “re-building yesterday’s business, but in micro-services and Java”.

At the same time, 5G looms, and unlike 4G, involves much more than improved radio modulation (faster, cheaper) – it is a two-edged sword. On the one hand it opens up on-demand services, new verticals that are latency dependent, and flexible broadband. On the other hand, it presupposes the existence of cloud, and its dynamic nature makes traditional configuration and optimization impractical. We must adopt entirely new methods if we are to benefit from 5G.

Cloud technology has already disrupted IT, enterprise networking, and the web scale industry (so called “FAANG”) and their closely associated cloud platform providers (AWS, Azure, Google Cloud, etc.). These firms’ business models differ dramatically from what we are accustomed to for one fundamental reason: they have dramatically different economics.

A web-scale cloud environment boasts some startling metrics; 10,000 servers per tech, true “lights out” datacenter operation, and problems that are repaired before they are service affecting. All of this stems from a modern, control theory approach to automation. In telecom we carefully script mechanization based on a thorough and detailed analysis of a network service. This works well if a) you only do it a few times, and b) you understand the problem and all its manifestations. Cloud-native systems, in contrast, utilize generalized closed-loop methods that are at once simple and highly sophisticated: they compare the desired state to
the current state (differential analysis) and continuously correct, scale, heal, optimize and load balance. No one scripts anything specific to a service or element.

Automation is the secret sauce of success. Automation drives up the productivity of both labor and capital, and, when done in a sophisticated manner, simultaneously increases agility (speed, across many functions), flexibility and quality (in terms of reduced error rates). Moreover, cloud and 5G technology create a volume of changes that would overwhelm manual methods. In industries from automobiles to semiconductors to cloud servers, automation has allowed prices to fall and innovation to increase. In doing so, it gives a huge cost advantage to the leaders – witness the global dominance of the FAANG firms, as well as Microsoft’s Azure, Intel and others who have invested in automation.

Consider, by contrast, the current situation in telecom. We are now 6-8 years into the NFV “revolution”. In 2012, 13 operators launched “network functions virtualization” (NFV), with SDN already underway. Yet, as of today NFV is not achieving high levels of automation and is rarely cloud native. By and large, CSPs offer the same services they always have, with a few bright exceptions (SDWAN on “universal” uCPE comes to mind). Most cloud and SDN exist as islands within a traditional network and traditional operations. This is not radical progress.

Inertia is our enemy. Multiple Tier-1 CSPs have expressed to us that they have conflicted internal strategy and operations. For example, many mobile operators want a cloud-native RAN & core, but at the same time demand unified, traditional operations across the 1000s of deployed physical mobile network elements, and the new virtual ones. This is a direct conflict, which means that the VNFs must be managed by legacy EMSs and must support traditional NOC operations. How does one undergo radical change while at the same time not changing? Not only is this an impediment to CSPs’ operational transformation, but it creates a quandary for network suppliers: deliver consistent operations or cloud native? We have to choose.

Furthermore, telecom seems to feel that we are “different” and that cloud technology, as practiced by Google, AWS and Azure, doesn’t apply directly to us. To be fair, there are differences in telecom, especially in widely distributed access networks -- both broadband fixed and 4G/5G RANs: datacenters are smaller (down to a single uCPE server in the extreme), and neither transmitters nor lasers/fibers/concrete can be virtualized. Yet none of these are reasons not to adopt cloud technology; we need only make adaptations for distributed datacenters, proximity, etc. And yet, we persist by re-inventing the core automation technology (MANO) which, in turn, demands new modeling methods and models. This increases industry cost and delays technology maturation. The net result is much lower levels of automated healing and scaling, and almost no automatic optimization. The economic result has been higher costs and less flexibility, at least so far. Appledore believe that the industry would be better served to adopt cloud technology as practiced by others, adapt it (at the margin) to our environment, and concentrate on how to leverage both the infrastructure we own, and the information that it generates.
The revolution announced in 2012 has been postponed, yet the promise remains as bright as always. This paper will provide a high-level scan of the opportunities we have, the choices we must make, and the critical best practices along the path to success.

CHOOSING A PATH

“If you don't know where you're going, you might not get there” Yogi Berra

“If you choose not to decide, you still have made a choice” Neil Peart (Rush)

These could describe Telecom today, where we still need to critically think about the business path we wish to take, and how to apply the cost and agility benefits of cloud to get there.

Low costs, combined with flexible operational models, deliver a secondary benefit; they create new revenue opportunities. With cloud, and the right business and operational infrastructure, it is suddenly possible to deliver services on-demand and for brief periods that were never previously economical. Similarly, cloud economics can drive down the cost of innovation, allowing profitable micro-segmentation, and targeted offers across verticals – expanding the revenue opportunity for the industry, and likely allowing improved margins as well.

This means that as we adopt new cloud and NFV technologies, we need to think deeply about what business models they open up, and what exactly we wish to accomplish with our new cost structure. We need to make a choice. First, we need to set up the basics: a) ensure that we maximize the savings, b) implement flexibility to innovate, and c) minimize integration and maintenance “taxes”. Next, we need to consider how we apply this cost structure to our business.

Massive, multi-year “transformation” projects have been (rightly) discredited in favor of gradual, continuous evolution. Furthermore, below we will argue for the operation of independent, self-managing domains which are loosely coupled via orchestration. Both are highly practical reasons why organizations must share a common “end goal” vision. Only when all organizations within a SP -- marketing and field operations, optical and RAN domains, IT and network -- share one common vision, can we make educated, coordinated decisions that get us to that vision, incrementally, but with a unified goal, and set of digital services, in our sights.

Back to decision making. Let’s keep it simple; at a high level, the industry can either:

1. **Ruthlessly focus**: Become the most efficient, “smart pipe” provider of access and core transport services. We can thrive as the low-cost “arms dealer” to all – optimizing our systems to make us the low-cost, flexible, and therefore high-margin commodity player.

2 Appledore Research Market Outlook “Cloud Native: The Revolution is Postponed”
While the industry has repeatedly shunned this outcome, evidence from other industries shows that this could be very lucrative, albeit boring.

2. **Innovate and grow:** Apply the flexibility, agility and new cost structure to expand service offerings and therefore addressable market revenues. One avenue of growth is developing new network-associated, value-adding functionality (authentication, BOBO . . .) to support the digital services of existing transport customers (especially B2B in new verticals, but also segmenting consumer), often on-demand. A second avenue of growth is to gain share in new vertical markets, trading generic terms like “IoT” for specific offers to specific verticals – e.g.: highly reliable, low latency coverage for industrial automation, and therefore taking a (small) share of revenues from new pies. In all cases it is essential that we leverage our strengths, rather than stray into others’ areas of expertise.

In reality there is no stark choice, but rather a spectrum of opportunity. At any point in this spectrum, we must ask ourselves; “What Digital Services do we wish to contribute into the Digital Ecosystems that are developing?” How far we progress along that spectrum is a function of both commercial ambition/strategy, and of the agility and cost basis of our network and management operational infrastructure. Either way, new cost structures open up new business opportunities, requiring us to specifically think about the complex business relationships that may exist in B2B and effectively serving other industries.

These new opportunities, in turn, demand that we change other operational norms – everything from core business analysis (don’t assume it’s costly and slow to develop a new product) to software architecture (need to support rapid innovation, and never demand bespoke integration). Path “A” demands that we drive down the costs, by an order of magnitude or more, of existing and closely related network services. Path “B” additionally demands that we support micro-segmentation, plan for rapid, low-cost innovation, and likely adopt new methods such as “continuous innovation”, “fast fail” and entirely new paths to market. Deeper into the business, we must create new methods for everything from ideation to product approval to go-to-market. Existing norms, honed under regulatory scrutiny, are likely to be impediments to progress. New facts demand new methods.
This graph illustrates the economic trade-off between traditional and service-oriented agile methods. Traditional systems are cheaper initially, with very low up-front investment. However, they scale terribly with development and integration/maintenance costs rising. Service-oriented methods based on re-use, by contrast, pay off when an operator wishes to innovate, in volume, rapidly – with the cost to create a new set of service variants (e.g.: to support the industrial internet, or a healthcare vertical). In these rapid-development cases service orientation results in a favorable cost curve.

THE IMPORTANCE OF AUTOMATION

Cloud is a means to an end, and that end is low cost and high agility. Cloud itself doesn’t necessarily get you there --- re-use and automation do. In many ways, nothing else matters. Re-use and automation go hand-in-hand. Automation can yield huge cost and agility improvements in operations; while re-use can yield similar improvements in innovation and new service creation. Furthermore, automation depends on highly standardized and well-defined network and service models – which result from re-use. Automation and re-use deliver many virtues:

- Reduce most repetitive operational costs to near zero
- Speed the agility and reduce the cost of innovation
- Make on-demand and dynamic services practical and economical
- Enable continuous self-management and optimization – including proactive healing, scaling, capacity management – of individual domains and entire networks
• **Handle the huge complexity and operational volume** necessary for advanced networks
• **Reduce** the points of integration (and associated cost)
• **Reduce** the scope of maintenance (and associated costs)
• **Improve quality and consistency**: reduces error rates dramatically

Most modern systems, from manufacturing (automated factories) to web development, have shifted to a paradigm where standard, modular components (software, hardware) are assembled into end products and services. In IT this is called a Service Oriented Architecture (“SOA”) and the individual components are called services (or commonly but misleadingly, micro-services\(^3\)).

Re-use of these services allows us to work smarter, rather than harder – since a “service” that is re-used 10 times yields (by mathematical identity) a 900% productivity improvement. At the same time, since a service is written and tested once, the error rate should be similarly improved while maintenance and integration are performed only once. Let’s do a quick summary – automation and re-use allow for an entirely new cost structure, with ten-fold (or more) improvements. Moreover, they don’t only deliver savings at the beginning of a project or a service, but continue to deliver savings for years, simplifying both maintenance and systems (re-) integration tasks which have slowly come to dominate IT budgets, leaving less for new technology and initiatives.

It is possible to achieve high levels of automation and re-use while, at the same time, simplifying the operations/software process. This, however demands that we approach the entire life-cycle holistically – which means working across artificial organizational boundaries, such as “fulfillment” and “assurance”. For example, while it is possible to create “brute force” logic to set up cloud services, heal them, and scale them, it is much more efficient to build a flexible, parametric model and consider healing and scaling simply as “re-orchestration, with new parameters”. For example, scaling might mean using the standard fulfillment method, but with a higher desired capacity, and a differential analysis against “as exists”. The key point is that ONE model and ONE method work at three different life-cycle points (new instance, and at triggers for scale-out and healing).

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3 Services may be of various sizes, from “micro-services” to “macro-services”. From direct conversations with leading WebScales, we can assert that the “right” size of a service varies greatly – but “microservices” has become a buzzword – and possibly a misleading one. The key is to have loosely coupled, well-defined, modular services.
Figure 2: One Common Orchestration Method

All the best practices (see table later) converge on one concept: *Keep it simple so it’s easier and cheaper to get it right*

Source: Appledore Research

**SUPPORTING PEOPLE AND PROCESS CHANGE**

“Knowing is not enough; we must apply. Willing is not enough; we must do”. Goethe

CSPs need to change more than technology to achieve our vision. The best systems and technical architectures are not enough without the capability to deliver operational and business change. Automation and process optimization will only occur if we deal with the human elements of change; how organizations, people, skills, ways of working and incentives need to be altered. As an example, our recommendation to create autonomic domains by technology (letting them manage themselves) requires significant cultural change from today’s CSP behavior. Effective change management of people’s roles, the processes they use, as well as how they interact with new systems is key to delivering this operations vision.

**THE BIG PICTURE – HOW THIS FITS ACROSS THE OPERATIONS LANDSCAPE**

**Revolutionary goals, evolutionary approach**

For over 20 years we have seen a constant stream of projects that aim at massive Telco transformation and legacy system replacement. The overwhelming evidence from these is they fail or become massively descoped, adding yet one more siloed operational system. Cloud native is an ambitious and revolutionary goal, but it needs to be achieved through evolutionary
and agile/small iterative steps. FAANG’s success has been tied to lots of iterative steps with a clear end point of transformation. Netflix did not simply go from being a video hire shop to the leading streaming platform in one single technical transformation.

An evolutionary approach is also important in bringing the operational team with you rather than making them impediments to change. An evolutionary approach allows for building trust in the new technology and approach. An evolutionary approach also allows for “continuous” learning in response to problems and failures. Toyota effectively disrupted the auto industry with a similar approach (“kaizen”) in the 1970s and 1980s – they made boring, small, improvements, but made 1000s of them. And they kicked Detroit’s butt!

**Service Creation – defining flexible model**

Service creation is the process of innovation - developing a new network or customer facing service, complete with operational support, monitoring thresholds, billing support, etc. In adherence to the goal of re-use, it is ideally the process of chaining existing small services together into larger ones, and when needed, creating new, re-usable services.

Unlike historical service creation, in a DevOps and closed-loop orchestration environment, a huge number of parameters – from scaling methods to acceptance test procedures to SLAs that must be monitored, are defined up front. This can make service creation incrementally more involved than in the past, but remember that once created it is intended to be a) re-used with little or no effort, and b) fully self-managing. As in advanced manufacturing, the up-front investment pays off in low marginal and operational costs and in uniform quality.

Modern, service-oriented creation should depend heavily on service (and resource) catalogs, which allow an innovator to browse building blocks, much like Legos®. Later the service catalog – complete with purchase options, can drive automated ordering processes, either via APIs, portals or both. Ideally a portal is nothing more than a “human window into API functionality”.

Once a service is created, and both the VNFs and the service are modeled, all of the data should exist to drive orchestration – initially for turn-up, and throughout the lifecycle to scale, heal and load-balance infrastructure – all without further intervention. Nice. On the other hand, if engineers try to “force” the system and take shortcuts, the elegant processes that follow will become a recurring nightmare.

**Independent, Self-Managing, Loosely Coupled Domains**

Every word in this title is important, and this concept impacts all other functions. Traditionally, CSPs have developed “end to end” management solutions for various services. This approach is slow, scales poorly and gives minimal re-use with significant integration costs. Tomorrow’s networks must become federations of independent, self-managing domains. Examples are the radio domain (managed by SON), SDN domain (managed by an SDN-C), SD-WAN domain (managed by an SD-WAN controller), and the NFV domain (managed by MANO or other cloud
systems). Beyond these will be legacy domains that are encapsulated and exposed as macro-services, and legally separate domains – such as when collaborating with industrial partners for IoT E2E services. The figure below illustrates Appledore Research’s guidance on domain-driven design⁴.

**Figure 3 Guidance for Development of Independent, Self-Managing Domains**

- There are *many reasons* to have multiple loops by technology domain, region or legal entity
- *Among them*: re-use, simplicity, containment, simplified abstraction, security, domain expertise

![Diagram showing domain-driven design](image)

*Source: Appledore Research*

The critical points are that individual domains must be allowed to manage themselves, and must be easily “consumed” or orchestrated by external systems (the SP’s service orchestrator or possibly a 3rd party in a digital collaboration). These have many corollaries, but the most fundamental is that access to services within a domain for fulfillment and assurance is abstracted, typically via an API. It is both impractical to try to access specific details, but more critically, any effort to micro-manage limits the ability of a proper cloud-system to optimize itself and heal, scale and allocate resources in the most optimal way. Beyond the technical reasons, there are practical reasons to, in effect, loosely couple domains. It makes it easier to add new technology domains, to add new vendors, to incorporate partner or leased capacity (e.g.; “aaS”) and to upgrade domain technology – all with minimal impact, minimal integration expense and minimal risk. We will see this again below as a best practice: “domain driven design”.

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⁴ “Domain driven design” (https://en.wikipedia.org/wiki/Domain-driven_design) is a well-accepted best practice, the term coined by Eric Evans in a book with the same title.
### Inventory in Federated Domains

Traditional inventory in its current form is an indication of the lack of encapsulation in current networks. Traditional inventory is a detailed representation of the network and services from end-to-end, intentionally including details across every technology and administrative domain. In a domain driven design this is not only impractical, but undesirable. Inventory must be distributed – “federated” – across individual domains.

In the new operational model increasing amounts of traditional inventory information will become encapsulated as “State” within a domain. This is necessitated by the highly dynamic nature of those domains (which are continuously self-managing), as well as practical limits to scale (CAP theorem). Inventory at its simplest will increasingly become trees of pointers, each pointing to an API which exposes the state, which might include a set of SLA variables. Inventory in this scenario can operate in an analogous manner to the web where pointers are used to link objects, and in which detail about pointed objects is cached for non-functional requirement needs, rather than forming a persistent, replicated version of the actual network.\(^5\) Note that this is in fact a service-oriented view of the network – which each domain delivers a service.

We do believe that an end-to-end view will still be needed. But rather than being a semi-static, and highly detailed view of the network, it is more likely to be a dependency tree, with each branch pointing to a service that is delivered by a domain. This will be critical for understanding impact on end-to-end services, and ultimately mapping those impacts to customers. In Appledore’s taxonomy we often refer to this as dynamic inventory and topology and dependence.

### Orchestration – the common method and the glue

Orchestration illustrates the new, service-oriented, automated philosophy well. Not long ago, if we spoke of orchestration, it was highly likely that we were talking about fulfillment. Yet they never have been synonymous – orchestration is a process that can be used to perform any set of conditional, logically ordered actions.

One of Appledore Research’s foundational best practices is that a single orchestration method must serve all business processes that impact any given network service or network element\(^6\). While we do begin with fulfillment, in a cloud or SDN environment, we need to realize that healing and scaling are merely changes to an “as built” network function or service. Scaling makes it bigger. Healing re-instantiates it to overcome a failure or congestion, but they are the same process, following the same model, against the same SLAs, etc. Once fulfillment, healing

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\(^5\) Appledore Research Market Outlook "Dynamic Inventory"

\(^6\) Appledore Research White paper, “Closed Loop Automation and the New Role of Assurance - Research Note”
and scaling are in place, we have the opportunity to link AI/ML optimization algorithms, and run orchestration as a continuous process, constantly “grooming” the network to allocate capacity most efficiently, for example freeing up stranded capacity left in place after hundreds, or thousands, of service provisioning orders.

By using a single method, many things are simplified. There is one model; we need not maintain multiple models nor keep them in sync. It also pushes us to build proper, parametric models and define the *intent* – allowing orchestration to pick the most beneficial way to realize that intent (where it is placed for instance).

We hope that it is becoming obvious that success with automated, multi-process orchestration depends heavily on building well thought through, flexible, intent based models as we discussed above.

**Service Oriented, and Automated Assurance**

Let’s begin with two highly related principles: independent, self-managing domains, and a single orchestration method (in each domain, and across them at the E2E service layer). These two principles begin to re-shape our view of assurance:

1. First, assurance must understand how a customer-facing service is dependent on a set of underlying component services, likely one or more in each of several domains. The details of each service are handled within that domain, but we must understand if it is meeting its SLA, or conversely, impacting our E2E service.

2. Second, since orchestration is responsible for performing automated healing, our obligation is to identify impacts on customer services, and ultimately customers (and vice-versa).

This radically changes our view of a NOC, and how one goes about handling trouble calls and network faults. The fact that, in tomorrow’s model, everything from service creation through assurance are service-oriented, and most actions are automated, creates powerful possibilities. Rather than worry about what caused a service impact, we can turn human expertise, which will always be the most holistic and flexible, to the “big picture” questions: What is top priority and why? What trends are we seeing that can be investigated? How can we eliminate entire classes of incident? What is the cost or failure, and the revenue/value of correction? These are topics that allow us to manage and optimize the business, rather than react to the network, and are at the heart of concepts such as “NOC to SOC” evolution.

**Analytics**

Analytics, Big Data, Machine Learning, Artificial Intelligence; call it what you will, will be a central function of any future automation. Analytics is what allows us to move from a fixed semi-static network to one that is automated, yet capable of constant change with the volume of change beyond a human being. Over time analytics will be applicable to everything from providing
predictive scaling and healing to an intent based service, all the way to developing marketing and investment insights.

Analytics allows smarter automation; moving from reactive automation (in response to faults or capacity shortfall) to proactive automation (e.g.: scale network in anticipation of immediate need). Over a longer time-frame it enables CSPs to forecast capacity demand further out – averting both the cost of wasteful over-provisioning and the delay inherent in reactive, one-off installations driven by service orders. Even in the last mile, where over-provisioning of capacity has historically been impractical, analytics gives the opportunity to predict and optimize the capabilities of 5G cells and network slices to appear to deliver an “infinite network”.

The power of analytics is only achieved if you can act on its recommendation. This will require the ability to drive encapsulated intent-based change (see earlier sections) but more importantly it will require the building of trust in the analytics recommendations. Successful analytic applications will have the building of trust as a core capability.

Customer and partner interaction (“everything is an API”)

“All teams will henceforth expose their data and functionality through service interfaces - Anyone who doesn't do this will be fired. Thank you; have a nice day!”

Jeff Bezos, Amazon CEO, circa 2002

In this, now famous, internal memo Bezos was “asking” everyone within Amazon to interact using web services. Every team had to decouple, define their resources, and make them available through an API. For HR to get numbers from marketing, they had to get them using an API. Each internal team within Amazon became a partner or customer of other internal teams.

Amazon transformed itself, internally into a service-oriented architecture (SOA), and externally from a bookseller to the leader in IaaS and cloud computing. Telcos need to achieve this same transformation in the way they work with customers and partners, and this needs to be API led.

“All service interfaces, without exception, must be designed from the ground up to be externalizable. That is to say, the team must plan and design to be able to expose the interface to developers in the outside world. No exceptions.” -- Jeff Bezos

We have already stressed the importance of service orientation and re-use. If service creators and model builders have done their jobs properly, the next step is to simply expose some subset of those services to customers, partners and to other technology or service domains. This is yet another form of re-use, and consequently should be relatively easy. Today's challenge is that most services are currently designed not from an external perspective, but rather to reflect a Telco’s view of its own infrastructure and operations. Rather than abstract the network into customer services consumable by anyone, distinct customer facing systems are “hard wired” to the underlying network and Telco business model. We want to emphasize that this neither serves
external clients, nor the loose coupling of domain driven design – in which another domain or process is the “customer”.

Finally, let’s discuss the relationship between APIs and customer/partner portals, and even internal portals: They should rely on the same logic and data, with portals merely being GUIs placed on APIs. This a) enhances re-use (again), b) ensures consistent operation, and c) minimizes both maintenance and integration.

In the end, APIs become a window into the already-existing services; internally, for wholesale partners and even for retail consumers. The only differences should be slightly differing granularity and permissions.

SUMMARY OF BEST PRACTICES

In this paper we have laid out the business drivers, desired future state, and the impact on various familiar areas of operations. In the future, the operational areas of fulfillment and assurance must be more closely linked, be based on common methods and models and must be engineered to leverage the synergy between them.

In this section we list the key best practices, for all areas of operations, that can improve the operation of cloud systems, and can simplify the engineering and maintenance of those systems. Most of these best practices come from a philosophy that may be foreign to many in the telecom industry: we must become comfortable with uncertainty. Why? Because “cloud” is constantly, dynamically changing and self-managing. We cannot easily know exactly where a workload is, at any given moment – and we are better off leaving that choice to “the machine”. Only in this way can a domain (say, SDN) proactively heal, quickly react to failures, and move loads around to best utilize datacenter (or optical transport underlay) capacity. Each of these best practices allows us to specify an OUTCOME, and yet leave the particular method and solution up to intelligent, closed-loop systems. The “best practices” below are intended to allow for the competing needs of end-to-end operation, and yet independent operation of domains – all with the goal of vastly improving re-use, and reducing the associated cost, time, maintenance and integration for any new service.

<table>
<thead>
<tr>
<th>Best Practice</th>
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<tbody>
<tr>
<td><strong>Model and Policy Based Orchestration</strong></td>
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<tr>
<td>“One shared vision” (essential for a large organization to make aligned decisions)</td>
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<tr>
<td>Intent based models and orchestration (reducing the tyranny of predicting the future)</td>
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<td>Comprehensive models, including DevOps artifacts (thresholds for monitoring, etc.)</td>
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<tr>
<td><strong>Catalog-Driven Operations</strong></td>
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7Appledore Research Market Outlook Reports: “Cloud Native” and “Control Theory”
8A deeper look at these best practices is available at: appledoreresearch.com/research-reports.
One (single) model and orchestration method for fulfillment, healing and scaling
Closed loop automation (building on proven best practices)
Service-Oriented Operations (creating building blocks, widely re-usable across operations)
Domain Driven Design
Embrace advanced intelligence (AI/ML) and algorithms over hand-crafted logic
“Everything is an API” (supports loose coupling and re-use)
Loose coupling (enabling autonomous domains)

CONCLUSION

Cloud technology offers an opportunity for once-in-a-lifetime improvements in cost, agility and productivity which, if adopted, can radically change our business and maintain the industry's competitiveness. In this paper we have argued that a huge improvement in cost and agility is within reach, but realizing this requires a new way of thinking about operations. We have argued that the entire organization must share a common goal, so that we can get there incrementally, but with a consistent destination. We have shown, at a high level, how various operational areas will be impacted, and argued that they must now depend on common models and software methods. Finally, we have provided a summary table of best practices that; a) simplify this process, b) ensure high levels of re-use, and c) reduce technical risk. In summary, we believe that realizing this opportunity will require:

1. Choosing a future business strategy that harnesses technology to realize clear business goals. Sharing that common strategy across all departments so that all can “pull in the same direction”. This facilitates a gradual and coordinated step-by-step migration toward the strategic business goal, reducing costs, risks and increasing the probability of long-term success.

2. Automation and re-use (not the underlying technology) are the key to success:
   a. **Automation** drives down the cost of repetitive tasks, and makes new business models practical.
   b. **Re-use** drives down the cost of innovation, service deployment and niche markets, leading to greater agility and market opportunity.
   c. Re-use (of models, ops logic, etc.) also pays *recurring dividends* in terms of vastly reduced SI and maintenance costs (maintain one object and simply re-use it).

3. Technology change without people and process change is pointless. We recommend beginning with business goals, continuing to new process concepts, the roles people must play and only then deploying supporting technology. Simplifying operations infrastructure will reduce the risks of technology change. But this demands re-thinking long-held assumptions and ways of working.
4. “Cloud” implementations can lead to high levels of automation. It is therefore critical that implementations maximize business benefit by adopting existing best practices:

a. A service-oriented architecture with loose coupling.

b. Intent-based service definitions and models.

c. Autonomous, self-managing domains → loosely coupled – via service level APIs.

d. **One, single orchestration method** that, depending on context, handles fulfillment, scaling, healing or ongoing capacity management.

e. Clear encapsulation of legacy to prevent the legacy approach, driving its recreation in the new environment.

We wish to leave you with two over-arching thoughts. First, tomorrow’s operations are distributed, and yet designed to be a single process of inter-related capabilities. Second, *this matters and will pay huge dividends*; the cost and agility opportunities are far larger than any previous technology change has offered. Let’s think differently and make the most of this.

**ABOUT THE AUTHORS**

Grant provides a unique combination of management and technical acumen, combined with 30 years of successful innovation in both technology and business models. He most recently served in the office of CTO for Ericsson. Through his career, Grant has specialized in transforming telecom software and service businesses in the face of dramatic market and technology shifts, positioning the businesses for survival and growth in new environments.

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9 Specifics are beyond the scope of any single white paper. We encourage readers to discover more at www.appedoreresearch.com and from nokia.com. Both have resources that look more deeply into modeling, control theory, orchestration, automated healing and other key aspects to this transformation.
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