LIQUID NET

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Abstract

Liquid Net *unleashes* frozen *network capacity* into reservoir of resources that can flow *to fulfill unpredictable demand*, whenever and wherever people use broadband. This paper tries to explain and inspire everyone about liquid net. Explain obstacles that exciting networks have and how new requirements in the name of liquid network architecture will tackle these barriers. Moreover how evolutionary Liquid Net new components and architecture should be in order to have minimum alternation for Telecom operators. To make these happen, principle like "Self-aware self-adapting" and "multi-purpose hardware" and "Inter-linked architecture" has been explained in three major layers of liquid net.

Introduction

Imagine a world where people are enjoying same quality of experience no matter which part of network they are and no matter what activity they are doing .If that seems like a dream come true then we should know more about liquid net. Everybody knows that data usage is exploding, but that is an unpredictability that is making a largest challenge. As more and more devices are broadband connected and grown variety of HD video and gaming are putting networks in vulnerable and constrain situation. So predicting a demand for internet services is almost in possible, on top of all these, end users want consume more but not pay more. Therefore increasing network capacity is unsustainable and it's tough. However managing unpredictable data explosion doesn't mean endlessly expanding the capacity. Liquid Net offers a much better alternative solution for current networks.

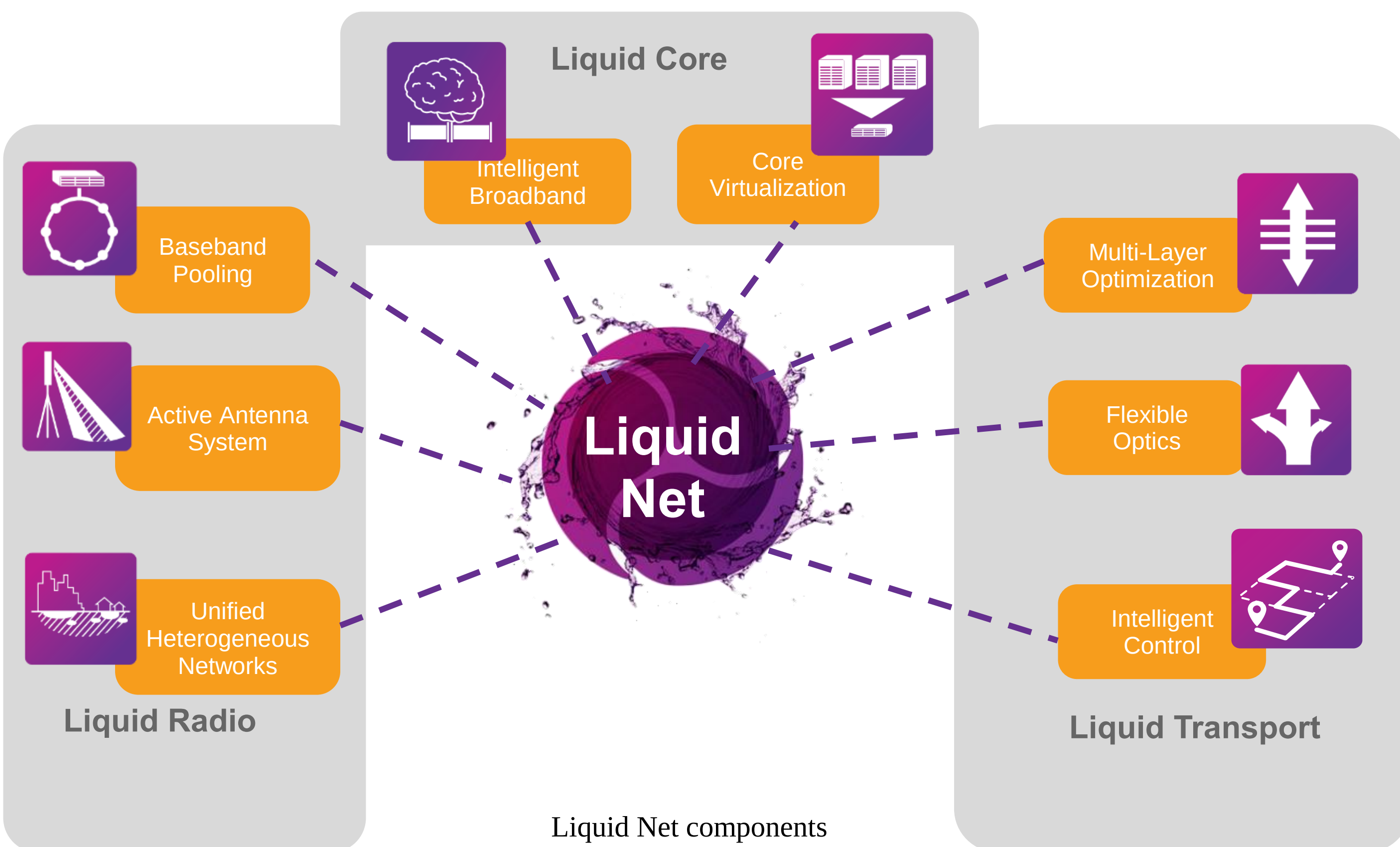
In a solid everything is packed tightly together in rigid structure unable to move around, but in the liquid everything can move around freely and it is not constraint to a fixed shape .Now imagine a network which is more like liquid and less like solid .It will be more agile, adaptive and responsive, consequently the network can perform better because capacity can move wherever and whenever it is needed. For example, a network can follow users from suburb to the city so all the capacity which stayed unused in day time in suburb area can get drag to the city to meet higher demand in the city during working hours. Liquid Net over turns conventional network wisdom with a new philosophy .Liquid Net creates fluidity seamlessly and intelligently across the entire network infra-structure not just in core network or radio access but also in transport section.

Liquid Net solution components

With Liquid Net we go well beyond radio access to extend the self-adapting coverage and capacity principles of the Liquid Radio architecture into the core and transport networks. This creates a completely new network architecture in which capabilities are fluidly and intelligently implemented.

Like a supermarket shelf of mineral water, the coverage, capacity and services in today's networks are bottled up - in individual radio cells, in separate core applications and stuck on transport layers. In effect, Liquid Net opens the bottles and creates a reservoir of resources that can be flowed intelligently to where they are most needed in order to satisfy users' thirst for broadband.

This new flexibility in networks maintains a high level of user experience by responding to traffic peaks. And this dynamic capability is matched by a transport infrastructure that intelligently and flexibly connects users to the service, content or application they want. In order to find system requirement for Liquid Net, it is better to divide the concept into three major network layers. A) Radio Layer, B) Transport Layer C) Core Layer. Then discuss more about functional and non-functional requirement of each layer separately.



Liquid Net components

Liquid Net Main Requirements

Liquid Net unleashes frozen network capacity into a reservoir of resources that can flow to fulfil unpredictable demand, wherever and whenever people use broadband.

This is achieved by intelligent, software-defined network applications running on multi-purpose hardware:

Self–aware, self-adapting: The network needs to be always aware of the user demand, service needs and its current operational state. Using built-in intelligence and real-time monitoring capabilities, a network can recognize where demand is coming from and instantly re-adjust itself to match that demand. In the Liquid Core this is achieved with Intelligent Broadband Management which enables the network to efficiently manage traffic by setting end-to-end network resources and by optimizing content and service delivery to achieve the best subscriber experience

Software-defined applications on multi-purpose hardware: Network applications, mainly hardware independent, defined by software and highly configurable, running on multi-purpose platforms, achieve flexible capacity across the network. Unlike conventional networks with dedicated software and hardware stacks, Liquid Net software runs on legacy and leading-edge processors, enabling the use of multi-purpose, shared hardware, for example ATCA-based or later using other generic hardware. This means that processing capacity can be pooled and re-allocated to where it's needed most, according to the application and location.

Inter-linked architecture: Infrastructure elements are extensively inter-connected to allow capacity and processing to flow freely across the network. Liquid Core provides CSPs with multi-purpose hardware architecture, with co-located core applications being distributed across CPUs and memory as needed to create extreme hardware efficiency. Network resources are allocated on-the-fly according to traffic and service demands and with the capability to adapt easily to new traffic profiles as they arise.

Investment-protection, Evolution: The fourth key enabler is non-disruptiveness. A real world solution needs to build on what is already there, even if it is a multi-vendor installed base. Innovation often comes at a price – the need to replace existing infrastructure with new equipment, wasting previous investments. So instead, Liquid Net should offer an evolutionary approach even if the results are also transformational.

Liquid Radio

The popularity of tablets, smartphones and mobile broadband connections has contributed to an explosion in data volumes in mobile networks. Customers can enjoy high data speeds on the move and value the wide-area availability of quality broadband connectivity. The pace of traffic growth will continue to rise, driven by ever higher penetration of smartphones, new applications, laptop connectivity and machine-to-machine communication (M2M).

New design criteria are needed to develop radio networks that can match these broadband speeds and rising data volumes. Network design must be flexible enough to scale to meet the demand of up to 1 GByte per user per day and data rates beyond 1 Gbps.

Let’s consider a scenario in which how exciting networks are struggled to provide coherent service to the subscriber, whereas by liquid net solution we can break and go through the problems.

Scenario 1

> *“There is a marathon match in Dallas, and participants have to run almost 42 km to reach the final line. Of course not only the Medias move along with participants to cover the match, but also the fans also move with their favorite athlete in order to cheer them. From network perspective there are unused resources that has left along the track of match till the participant pass those area so it get use either by media or by fans. In the other hand there are resources along the track which due to overcrowded of the fans and media, cannot handle all requests and demands, therefore it responses “network busy” and makes the subscriber frustrated and stop using the network and consequently operator loses revenue while there ideal resources in some other end of Marathon area track.”*

As explained in scenario we can extract many problems with conventional solid network architecture; For instance, As of the match might be international event, probably not all fans has the latest technology handset, so network should be ready to host all types of handset capability, from GSM to LTE. In the other word network should be in heterogeneous architecture with the smooth radio connectivity .Later the network should able to self-adapt and self-optimize itself base on the subscriber request.

First step is to transition towards software defined networks which deliver any mobile operator’s services and apps flexibly. Radio access networks change according to different needs and are sufficiently flexible to address multiple use cases in the best way possible. The evolution goes towards a mix and match of radio elements, multi-radio and multiband which provide a smooth **radio connectivity** access to any type mobile devices. Multi-radio is achieved with multipurpose hardware, typically based on a system-on-a-chip as the programmable unit at the heart of the radio network elements. Multiband is extremely important considering how costly and scarce at same time is spectrum for mobile operators. Wider bandwidth, multi carrier and programmable power amplifiers together with advanced techniques to fight and manage interference are essential tools for increasing efficiency and making the best out of spectrum asset like reframing does already today.

When those radio elements get combined in different ways we end up creating **heterogeneous architectures** that translate into Heterogeneous Networks. Multilayer networks operating simultaneously on multiple frequency bands and delivered thru different radio access technologies at same time promises a great individual user experience.

Operating and optimizing complex heterogeneous systems presents several key challenges, such as how to distribute traffic efficiently between cells and layers while guaranteeing seamless user mobility, how to alleviate the impact of interference and how to adapt the system efficiently to meet changing traffic demand. So**, management and operations** must quickly turn network to be self-aware and adaptive.

Active Antenna System

In active antenna capacity, we have three major challenges: First, delivering coverage and capacity. Secondly, expand Macro capacity in Antenna. Finally, total cost should justify the benefits of improved coverage, higher throughput and improved end user experiences. To overcome these challenges we need some requirements such as :

I. -Intelligent beam forming and feature controls enable new ways for sites to leverage existing macro base station infrastructure
II. -Enables one sector to become two software- defined and automated cells to address fluid demand
III. -Multi-radio, multi-standard and multi-carrier support
IV. -Highly efficient resource utilization optimize spectrum and supports micro layer design from same antenna location

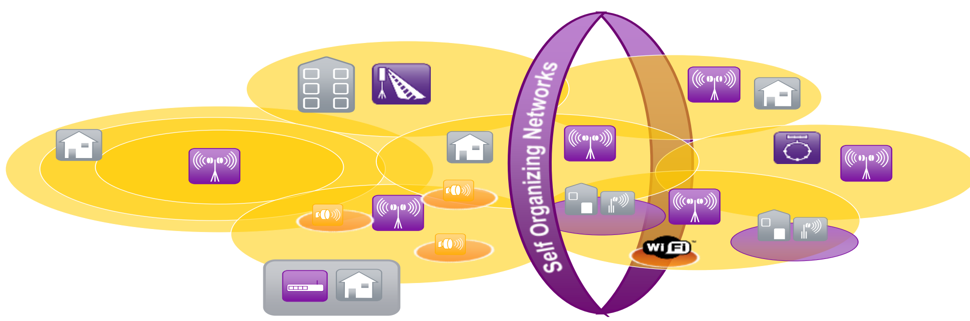
Hence by fulfilling active antenna requirements we can have privilege of having the small RF units that can be independently steered to create dynamic beams and therefore improve network capacity. Plus needs for a traditional base station to be installed on a site disappear and is replaced by an antenna. All it then needs is a power connection and a fiber connection to the centralized baseband or other type of data connection.

Baseband Pooling

In current trend of Telecom network architecture, operator are using and adding new technology to their exciting network very often. So they ended up having variety of architecture such as 2G 3G and LTE (4G) and later LTE-A. This brings lots of challenge in terms of signaling for the network. Plus in some case the radio station might be so busy in terms of signal processing which ended up rejecting new attempts. To avoid this issue Liquid Radio proposed a new idea which is called Baseband Pooling. In this solution instead of processing signal link in each radio station, all signaling has been processed by a pool of signaling processor in a Base station, therefore there won't be call rejection plus smooth inter cell handover is achieved. The requirement for baseband pooling due to use of different spectrum are either direct point to point connections or passive CWDM (Coarse Wavelength Division Multiplexing) connectivity.

Unified Heterogeneous Networks

For sure there is not any operator who works with single telecom vendor (CSP). Operator like Verizon has different radio access node in different places from different company. And within each vendor there are different standards and layer for different technology. So all these Multi-layer, multi-vendor, thousands of multiple variables and interoperability increase level of expertise required by systems demands more human interaction. To unified heterogeneous network, we require a Self-organizing Network. SON is an industry standard term for managing network capacity in LTE, HSPA and GSM networks. It has three building blocks: *self-configuration, self-optimization and self-healing*.



Self-configuration is a mechanism for automated network integration of a new base station by auto connection and auto configuration. After the installation Self-optimization tunes the network with the help of device and base station measurements. Self-planning on the other hand is a dynamic re-computation of network plan following changes of capacity extensions, traffic monitoring or optimization results. In an operational network self-healing will help in automatic detection and localization and removal of issues. We want to take it to advanced level to make it predictive i.e. self-healing takes place before any alarms are triggered.

Liquid Core

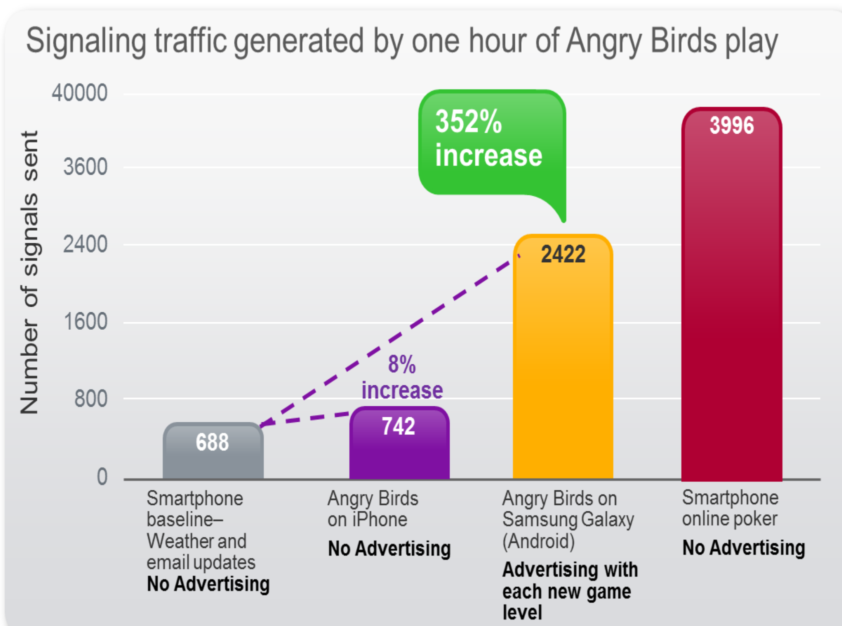
With Liquid Net we go well beyond radio access to extend the self-adapting coverage and capacity principles of the Liquid Radio architecture into the core and transport networks. This creates a completely new network architecture in which capabilities are fluidly and intelligently implemented. Like a supermarket shelf of mineral water, the coverage, capacity and services in today's networks are bottled up - in individual radio cells, in separate core applications and stuck on transport layers. In effect, Liquid Net opens the bottles and creates a reservoir of resources that can be flowed intelligently to where they are most needed in order to satisfy users' thirst for broadband.

This new flexibility in networks maintains a high level of user experience by responding to traffic peaks. And this dynamic capability is matched by a transport infrastructure that intelligently and flexibly connects users to the service, content or application they want.

Let's consider two scenarios in which how exciting networks are struggled to serve subscriber's unpredictable demands, and how current hardware architecture suffer the lack resource sharing in between nodes.

Scenario 2

The advertising pattern displayed by the Android version of Angry Birds is not unique to Angry Birds, but is common among many other free apps on the Android platform as well. In the Nokia and Apple marketplaces, apps tend to have a "lite" version that is free, then a fuller version that can be bought once someone has enjoyed playing the free version and wants to play more. The Android Marketplace, on the other hand, tends to offer fully "free" apps that generate revenues through the inclusion of mobile ads that are sent afresh, in the case of Angry Birds, with each new game level that the smartphone user plays. That adds up to a lot of little connections to the network when end users are playing an Android-based version of Angry Birds, versus almost no active network connections in the Nokia and iPhone versions. Understanding this kind of difference in behaviour helps operators predict exactly what kinds of volumes of signalling and data traffic to expect if, for example, the number of Androids in their network increases.

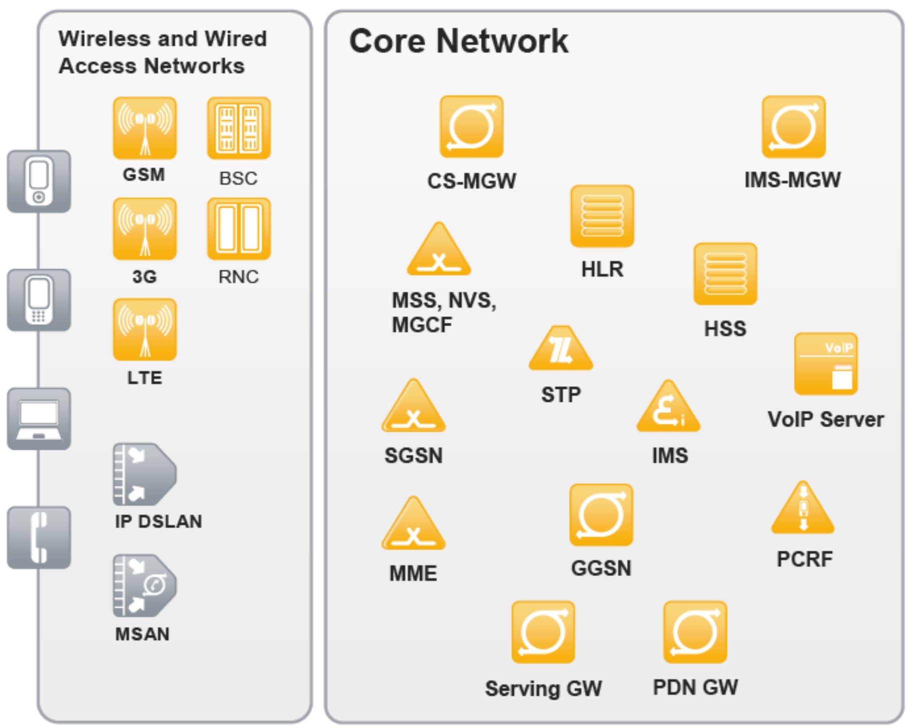


Scenario 3

Assume that one of the well known TV program like a "Late Show" is broadcasting. After sometime a TV host conduct a quiz and asks the audiance and people, who are watching the show,to sms the answer to the number which it is displayed . Now there is going to be milions of text sms to that sms center. An unpredictable demand in SMS, results some of the messeges get barred or get drop and never reach the program. And this is becuase SMS center overloaded at that particular period. Whereas other center in same core network like VMS (Voice Massegae Service) is working ideal .

As explained in scenario 3, the problem with current and exicting network is; in the same core location where different server are located, one server can get overloaded at some periods of day or week whereas other servers which are working ideal, can not get involve and share the load. Scenario 3 is a sample for bigger picture problem.Conventional core networks, typically comprising Circuit-Switched, Packet-Switched and IP Multimedia System have grown in complexity caused by adding purpose-built software and hardware for each new function - MSS for switching traffic in the Circuit-Switched domain; PCS for setting policies to assign resources; or HLR to hold the subscriber profile, etc.These applications do not scale up efficiently in line with traffic demand and are difficult to evolve to meet new demamnds. And proprietary hardware cannot keep pace with the fast development of generic hardware development.

The transformation of core networks must achieve significant improvements in cost-effectiveness and must also deliver virtually unlimited scalability, adaptability and efficiency, without disrupting the existing customer experience. Future core networks must also be able to evolve seamlessly to support new applications and services while optimizing investments.



Multiple core platforms make consolidation and co-location difficult

In order to solve the conventional network, Liquid Net has two major solutions in the core area (1) Virtualization and (2) One Common Hardware.

One Common Hardware

In the past, many applications in the core network selected specialized proprietary hardware as there was no “one-size-fits-all” hardware platform available. As the Advanced Telecommunications Hardware Architecture (ATCA) designs have matured in recent years and now offer the kind of functionalities and quality expected from a future proof telecom platform. ATCA helps the telecom specific requirements such as long lifecycle for hardware, high availability and regulatory compliance, small footprint and high capacity. In addition it enables co-locating more applications into a single network element and even multiple network elements into a single equipment shelf.

Complete core network in a single and synergic Open Core System

Virtualization

Virtualization is one of two pillars of Liquid Core solution. Core applications are the ‘intelligence’ of a core network. Core Virtualization enables any software application to run on ATCA and ultimately on other generic multi-purpose hardware. As well as enabling the re-use of legacy hardware, hardware-independence enables the CSP to take advantage of the latest processor technology developments. Core Virtualization also brings extreme hardware efficiency and extreme flexibility by flowing capacity to the right spot to handle differing traffic needs.

Core Virtualization goes much further. With a virtualization layer between the software and hardware platforms, all core applications are implemented in a single software set, eliminating the need for separate hardware dedicated to specific functions, such as HLR, IMS, MSS, and SGSN. This sweeps away the restrictions of conventional core networks which require CSPs to make significant investments in new hardware when they add functions.

Core Virtualization enables the entire core network to run on the same generic multipurpose hardware, tapping into almost unlimited processing power. With core applications using the network’s resources as they need them, the total available capacity within the network is used as efficiently as possible. Total Cost of Ownership (TCO) is reduced significantly. A Liquid Core uses far fewer hardware modules, reducing the level of CSP investment, but also bringing other cost savings. Hardware installation, commissioning and configuration are simplified. Up to 80% less floor space is needed. Spare parts stocks and the resources needed to manage them are reduced.

Liquid Transport

Liquid Transport innovates with new optical networking functions and adding intelligent control capabilities to bring transformation and optimization across all the transport layers. This introduces more flexibility into the lower layers and enables the network to adapt to the changing needs of users, the services being used and the operational state of the network itself. Liquid Transport channels traffic along the path of least resistance through the network to get to where it is needed, with high availability, low latency, no jitter and high Quality of Service (QoS).

Unlike the Core and Radio part Transport layer does not have tangible example or scenario in order to understand how it improves the network quality in liquid manner for non-technical people. There are many jargons, abbreviations and definitions which make the explanation more complicated and beyond the scope of this paper. However for the sake of comprehensiveness it worth to mention some functional and non-functional approach for this layer as an interconnect layer.

Next paragraphs emphasize how liquid transport layer helps other layer in more non-functional manner to fulfil their functional requirements.

Intelligent Control

A multi-layer intelligent control plane is introduced to the network to enable flexible, rapid and easy network operation and service provisioning, what we call 'services in seconds'.

The intelligent control plane uses an advanced planning tool, integrates the Operations Support System (OSS) and adds a central path computational element (PCE) to simplify operations and, ultimately, to enable automated service switching.

Intelligent Control enables fast provisioning of services, helping a CSP to bring new services to market very rapidly to gain a competitive advantage and with much lower costs because less manual intervention is needed.

Flexible Optics

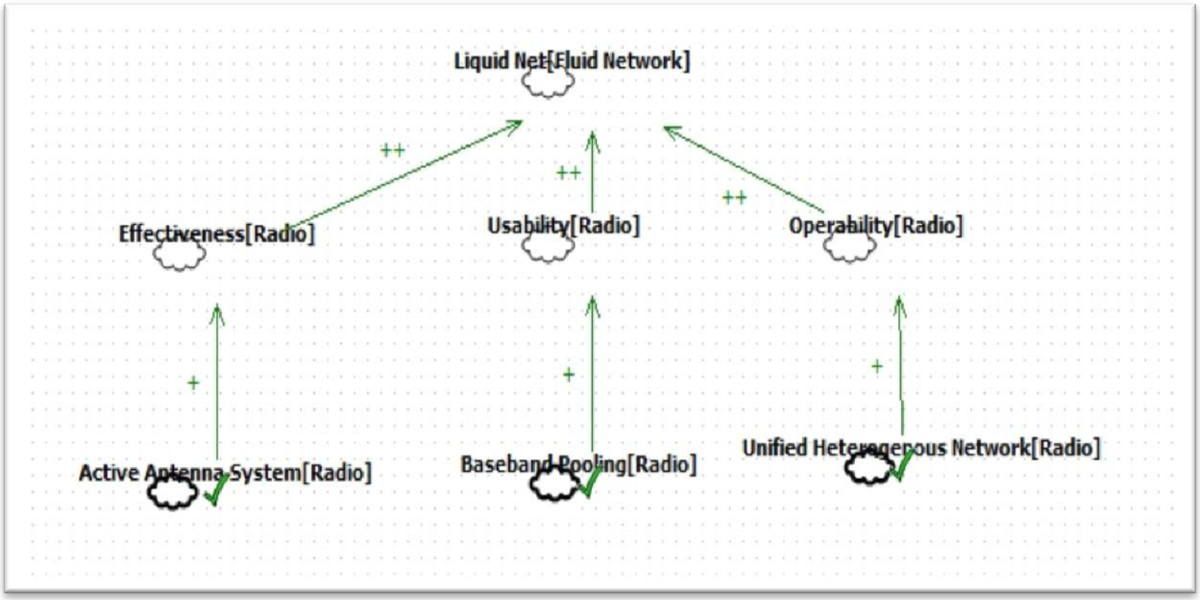
By making the optical transport layer, the lowest layer with the least total cost of ownership (TCO), more flexible and software-configurable, more traffic can be carried more cheaply than on the IP layer, removing many of today's network scalability and cost constraints, and supporting rapid service provisioning and low latency: what we call 'zero-constraint networking'.

Liquid Transport Flexible Optics implements greater functionality and intelligence on top of the existing Dense Wavelength Division Multiplexing (DWDM) and Optical Transport Network (OTN) layer. Flexibility is enabled by software-defined bitrates and reach per interface, increasing flexibility of use and avoiding costly re-installations. Using Coherent Transmission technology enables faster network speeds without sacrificing reach. Highly flexible switching at optical and electrical layer provides the basis for quickly adapting services to changing needs.

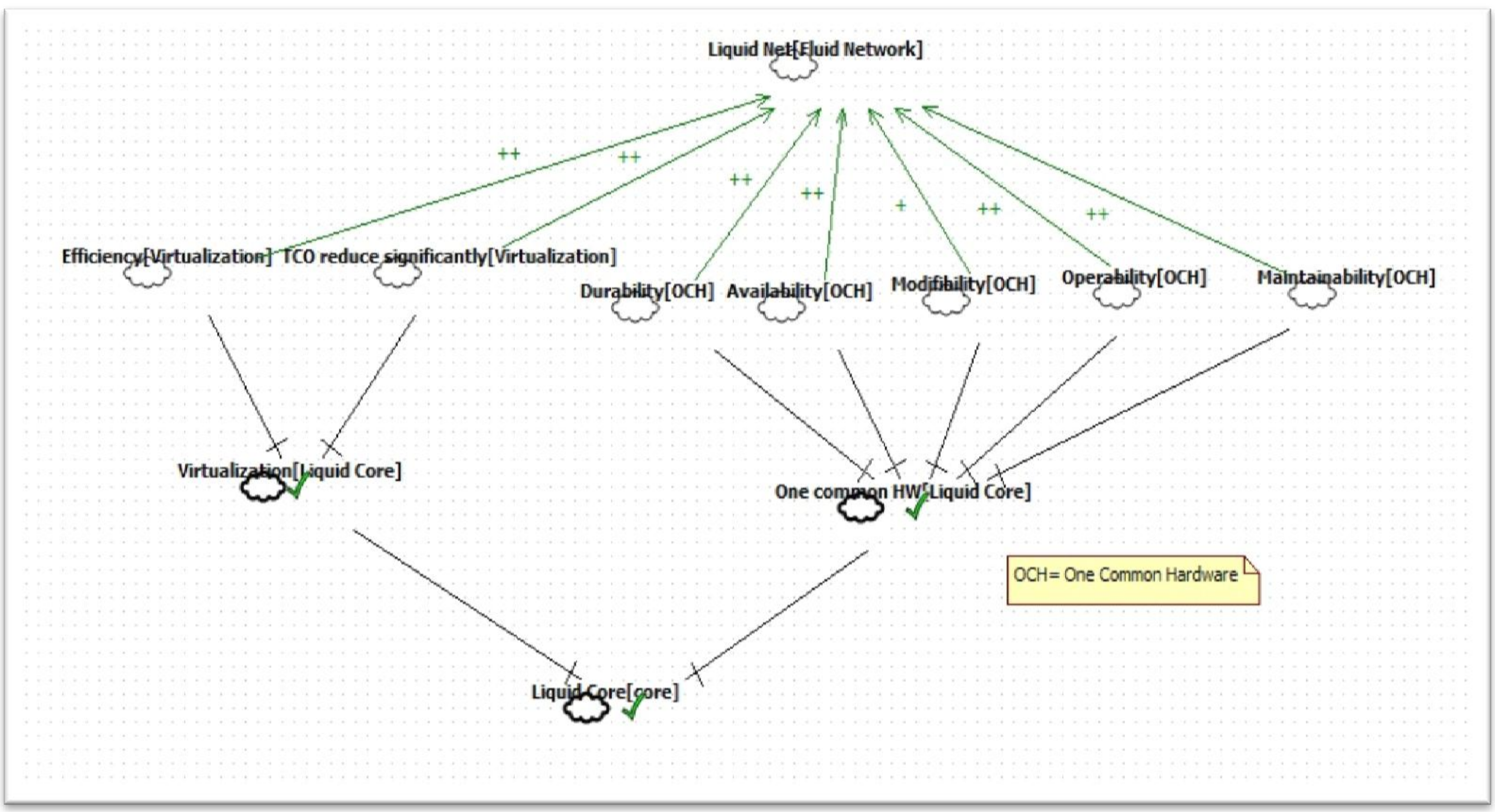
Multilayer Optimization

For maximum efficiency between the optical and the IP layer (360' network design), transport networks must be planned and implemented holistically across all networking technologies, including in particular radio and core – and across different vendors. The guiding principle for this is Multi-Layer Optimization, which is the regular optimization across all network layers to ensure that – while moving to packet - as much traffic as possible flows across the lower network layer with the most efficient topology.

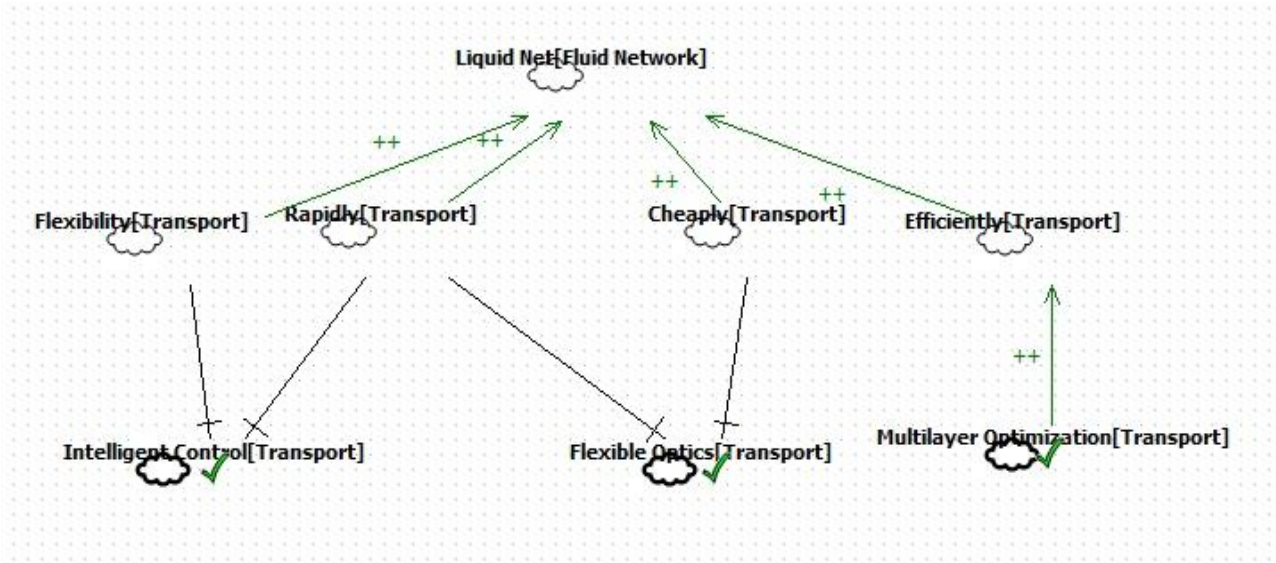
Nonfunctional Diagrams: Liquid Radio



Liquid Core



Liquid Transport



Conclusion

Subscriber demands make communication market to push CSP to provide more capacity everywhere every time cheaper than before. In order to meet these requirements, CSPs should go for something different as they are doing for past decades. The best solution currently is liquid NE unleashes frozen network capacity into reservoir of resources that can flow to fulfill unpredictable demand, whenever and wherever people use broadband.

Abbreviations

ATCA	Advance Telecom Computing Architecture
BSC	Base Station Controller
CSP:	Communication Service Provider
CWDM	Coarse Wavelength Division Multiplexing
DWDM	Dense Wavelength Division Multiplexing
EPC	Evolved Packet Core (for LTE)
GGSN	Gateway GPRS Support Node
GPRS	General Packet Radio System
GSM:	Global System for Mobile Communication
HLR	Home Location Register
HSS	Home Subscriber Server (for LTE)
HSPA:	High Speed Packet Access
IMS	IP Multimedia System
LTE:	Long Term Evolution
LTE-A:	Long Term Evolution-Advance
M2M:	Machine to Machine
MME	Mobile Management entity (for LTE)
MGW	Media Gate Way
MSS	Mobile Switching center Server
OTN	Optical Transport Network
OSS	Operations Support System
P-GW	Packet data network Gate Way (for LTE)
PLMN	Public Land Mobile Network
PSTN	Public switch Telephone Network
PCE	path computational element
PCS:	Policy Control Server
PCRF	Policy and Changing Rules Function
QoS:	Quality of Service
RNC	Radio Network Controller
RF:	Radio Frequency
S-GW	Serving Gateway (for LTE)
SON:	Self-Organizing Networks
SGSN	Serving GPRS Supporting Node
STP	Signal Transfer Point
TCO	Total Cost of Ownership
VoIP	Voice over IP