The interdependency of telco- and non-telco networks with a focus on increasing risk and resilience, a new use case for network convergence

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Abstract: Convergence happens at different levels, fixed and mobile, smart grids, network sharing. Future risks in interruptions are not only intrinsic to telecommunications networks, but increasingly inter-relate with events in non-telco networks. Resilience concepts need to adapt accordingly.

1. Introduction

This paper intends to review the topic of network resilience and failure recovery from a new angle. Historically work on failure, resilience, and recovery mostly focused on networks operated by a single network provider and took a network-intrinsic look at risks and respective countermeasures. Both have been well understood and provided sufficient levels for reliable network operations.

A series of natural disasters as well as man-made network outages have shown that this view is no longer sufficient. Such events showed that the increasing interdependency of telecommunication networks with other types of networks, in particular energy and electricity related, resulted in severe network failures. In Germany, a whole region was cut off from all basic infrastructure services due to flooding caused by massive rainfall during a single night. Hence, future work on resilience will need to analyze the risks and develop respective resilience and recovery concepts for a minimum of three layers:

- Inner resilience of a telecommunications or energy network, operated by a single provider.
- Outer resilience, i.e. resilience of networks built and operated by several, independent network providers.
- Outer resilience between telco and non-telco networks.

This listing shows that it is necessary to review the broader topic of network resilience with a focus on convergence, i.e., the impact of combining two services, technologies, or even networks. Typical drivers for convergence have so far been the synergies resulting from the combination of two approaches or technologies, and respective efficiency gains and cost savings. We will focus on the investigation of three types of convergence in the context of resilience:

- Fixed-mobile convergence.
- Convergence between telecommunications and power grid: smart grids
- Commercial and technical aspects of network sharing between operators.

2. Network Convergence

2.1. Fixed Mobile Convergence.

5G and especially the newly specified 5G core allows much better integration of fixed line and non 5G access technologies than the cores of the previous generation. The reason for that is a consequent separation of user (data) plane and control planes. 3GPP and BBF [1] have jointly developed a framework and standards for 5G based wireless wirelines converged, i.e. fixed mobile convergence. They mostly address 4 areas*:*

- Customer centric convergence, which directly impacts user experience and is usually recognized by the customer. A typical example is a seamless switchover form cellular to WiFi,
- Business centric convergence, which is common service layer for both fixed and mobile for example common voice services or single IPTV platform and capabilities,

- Functional convergence, which focuses on convergence on a functional level between mobile functions and fixed functions (e.g., converged User Plane and single control plane, common user database, common policy framework, etc,
- Structural convergence, representing synergies between Fixed and Mobile in “lower” domains, mainly in infrastructure, transmission and convergence of assets for example joint planning, or joint deployment of fiber for fixed access and mobile backhaul.

In the context of resilience, FMC-control-plan delivers the control capabilities to switch over seamlessly from different access technologies in case that one technology is affected by a natural disaster. On the other hand, joint planning convergent infrastructures must be carried out very carefully because additional dependencies of links and nodes can be created. For example, it might be very beneficial from pure cost perspective to share a link and nodes for mobile-network and fixed-network backhauling; on the other hand, it creates significant risks that a failure will affect both networks at the same time. From a resilience perspective it would be preferable to design independent backhauling and aggregation networks. Independence in this sense even comprises the utilization of different links and buildings, which not share the same cables and infrastructure.

2.2. Convergence of telecommunication and power grid: Smart Grids.

Handling of new sustainable electrical power sources and the trend to highly distributed electrical power sources like roof top installations of solar panels, and home battery buffers require a new distributed control plane for the power grid. Usually the combination of the power-grid and the new control intelligence is named as smart grid. IEEE defines the smart grid in the following way: The smart grid is a revolutionary undertaking entailing new communications-and-control capabilities, energy sources, generation models and adherence to cross-jurisdictional regulatory structures. Successful rollout will demand objective collaboration, integration, and interoperability among a phenomenal array of disciplines, including computational and communications control systems for generation, transmission, distribution, customer, operations, markets and service provider [2].

The risk that failures of communication network or power grid influences each other is obvious. In order to minimize the dependency, operators install backup battery capacity and diesel generators top keep the network running. On the other hand, the power grid increasingly depends on high availability of telecommunication networks. With the extension of smart grid solutions to the lowest level of the power grid, which is the distribution network to the customer the dependency of both infrastructure increases significantly.

2.3. Commercial network sharing concepts

From commercial perspective not all radio sites equally contribute to the revenue of the operators. If one ranks all cell sites by the average number of customers connected to them, which is an indication of the contribution of the sell cell site to the overall revenues, it usually looks like the following: 10% of the sites stand for 50 % of the revenue and 50% of the sites contribute only to 10% of the overall revenue [3]. On the other hand, customers expect 100% coverage and a good service everywhere. Therefore, mobile operators have developed different solutions to share networking resources in areas of low customer density. GSMA and 3GPP have developed different modes for resource share, starting with simple mast sharing and going to more complex solutions like MOCN (Multi Operator Core Network) and MORAN (Multi Operator RAN) [4,5].

The approach of resource sharing is needed to operate many mobile network sites commercially. From a resilience point, however, network resource sharing creates additional risks for a complete blackout of given region, because operator may share backhauling link, buildings, and power backup resources.

3. Common risks

3.1. Increasing risks of natural disasters

In their reports about climate change IPCC analyses the dependency of increasing average temperature and natural disasters like river floods, heavy precipitation, or increasing ocean level [6]. They forecast a significant increase of intensity and frequency of heavy precipitation. This and other secondary consequences of global warming has significant influence function and reliability of infrastructures like telecommunication and power grid. The risk of flood and heavy precipitation is increasing significantly in areas of Germany, but also in general. In July 2021, Germany faced a natural disaster, in which extremely heavy remain led to a sudden, dramatic increase of the level of relatively small rivers and destroyed a significant amount of the infrastructure in the impacted valleys [7]. Because of strong erosion of the ground by massive water flow and flooding of buildings, the telecommunication infrastructure was nearly destroyed as well. Building with systems of fixed and mobile networks were flooded including backup systems and generators, even street cabinets, cable ducts and trunks got lost. Because of network sharing and because of the intensity of the disaster even networks of DT competitors got lost, so that consequently an entire area was without any telecommunication services after the floods. The power grid broke for most areas, too.

4. Summary of learnings and recommendation

It can be expected that the risk of heavy precipitation and flooded and even risks of other natural disasters will significantly increases due to climate crises. To ensure a minimum of function of critical infrastructure, especially power grid and telecommunications, it is necessary to redesign the infrastructure. Especially it is necessary to consider the increased risk and the dependencies of the different services and network related infrastructure. Increased risks must be modeled and calculated and, for example, maps of water level in areas under the new heavy rain conditions have to be calculated and published by the local government [8]. Based on such information, telco infrastructure and even location of builds must be redesigned in order to deal with increasing flood levels. Even then building and power supply may be affected. It is, therefore, recommended to analyze the dependencies of different telecommunication infrastructure, to develop new design rules for telecommunication systems. Especially additional dependencies, e.g. as a result of site sharing and fixed-mobile convergence, have to be considered. In addition to a design of a more reliable infrastructure, IoT and massive sensing can significantly help to analyze risk conditions in real time to forecast the risk and to warn people via cellular networks in real time.

5. References

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