Rational Transmission Architecture

Netonomics provides optimized network architecture designs with unique target accuracy and network efficiency. This is achieved by an integrated method combining novel powerful algorithms, aligning all traffic flows simultaneously on a network level, as opposed to current route-by-route methods. Network efficiency can be optimized for transmission cost, reliability or performance. Realistic modeling of triple play services ensure accurate and verifiable results. The versatility of the methods allow for optimization of core or access networks based on any transport technology on any media. The improved utilization of capacity for a given demand, performance and resilience provides costs savings amounting to multi MUSD per year.

The Netonomics Advantage

The requirements on today's communication networks with respect to reliability and service quality are often higher than their actual performance. Netonomics offers network optimization to achieve maximum efficiency with respect to cost, service quality and reliability.

Network cost depends in addition to direct equipment cost on the amount of transit traffic and the transmission distances. Some examples of the direct advantages of a rational network optimization are:

- Minimizing transit traffic decreases cost, since transit traffic occupies more resources than direct traffic; at the same time, the risk of congestion is reduced (delays and/or packet loss affecting QoS).
- The simpler the traffic paths, the easier they are to supervise and route efficiently.
- The shorter transmission paths, the less exposed the traffic stream is to link or node failures.
- Large traffic volumes are routed locally: In 4G access networks, handovers benefit from a link as short and resilient as possible (X2 interface); In 4G and 5G, C-RAN introduces strict requirements on high bandwidth, low latency and resilience.
- The transmission distance affects cost by the need for longer cables and ducts, repeaters, relays, higher masts and/or specific radio site requirements.
- An efficient architecture allows for partial or step-wise implementation, as well as expansion while minimizing the risk of disruption in other parts of the network.

Why is This Not Standard Practice?

Planning a network optimally is a difficult task for a number of reasons. The complexity of resource planning is mainly due to that a large number of traffic streams are competing for the same network resources. A small change in the topology can have large consequences for the traffic flow, and thereby greatly affect cost or performance.

Furthermore, the number of possible network configuration grow very fast with network size. A network connecting 5 cities can be built in roughly 700 ways, whereas a network connecting 10 cities can be built in 34 trillion ways. Even in fairly small networks, it is impossible to evaluate all configurations.

Network design problems are known as $\mathcal{NP}$-hard. For an $\mathcal{NP}$-hard problem, there is no known algorithm that produces an exact solution in realistic time.

In addition, any change in a network may render an originally optimal topology suboptimal. Therefore, network optimization is advisable in conjunction with any network restructuration such as expansion, fusion, change of transmission media or cloudification.

Core Network Optimization

A core (or backbone) network transporting large volumes of traffic between distant parts of a network is ideally robust to traffic congestion and link failures. In any network, it may happen that service quality deteriorates due to capacity bottlenecks. Traffic that is routed through such a bottleneck is then blocked or delayed even when there are sufficient resources to carry the traffic in other parts of the network. Similarly, some parts of a network may be disconnected due to a reliability bottleneck in a failure situation.

Dynamic routing techniques can only circumvent such bottlenecks to a certain degree and may also cause network instability when resources are distributed suboptimally. To achieve the best possible network operation, however, the network topology has to be based on the optimal static allocation of resources.

The service quality delivered by a network is dependent on both the topology and the node configurations (system characteristics such as admission regions and buffer sizes). Therefore, traffic engineering and nominal capacity dimensioning needs to be an integral part of a thorough network analysis. In addition, channel management via trunk reservation or other priority mechanisms need to be determined to achieve maximum resource utilization for any given topology and QoS requirement.

Access Network Optimization

Design principles for access networks differ from the ones for core networks due to that the architecture is hierarchical and the number of nodes is much larger. The lowest hierarchies are defined by clusters of access nodes. The next hierarchy consists of concentrators aggregating traffic streams onto higher capacity links that connect to the core. Concentrator capacity influence the size and composition of clusters.

In access network design it may be necessary to determine the number and size of clusters, its members, the location of the traffic concentrators, and interconnections between all nodes within and between hierarchies. In 4G and 5G, resilience in the access network is becoming increasingly important, particularly in a C-RAN context.

Flexibility

Heterogeneous networks, built up with different technologies and carrying ever more sophisticated services, need to be modeled realistically in order to achieve accurate results in their analysis. With Netonomics' methods, any network can be represented accurately regardless of the transport technology used (SDH, ATM or IP), physical media (copper wire, radio link, optical fibre), type of access (fixed or wireless) or manufacturer in any combination.

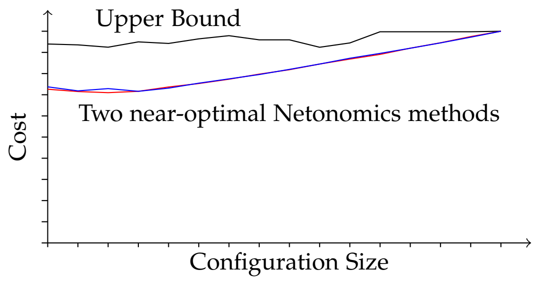
Similarly, traffic needs to be accurately modeled for a correct analysis of the effects of aggregate traffic on network components. The models used are scientifically proven, capture the characteristics of various traffic types, and lend themselves to analysis in a network setting.

Verifiable Results

The optimality of an architecture is indicated in various ways. Tight approximations with known maximum deviation from optimum indicate the possible optimal cost ranges. By using several mutually independent methods on the same problem, strong evidence of optimality follows when the outcomes from these methods are similar.

Service quality or robustness to link failure are verified by analytical and/or numerical methods. This approach allows for "what if" scenarios, sensitivity analyses and decisions based on realistic simulated data.

The following figure shows cost-optimal solutions obtained by Netonomics methods. The closeness of the lines clearly indicate the accuracy of the solutions, both representing solutions very close to the theoretical optimimum.



Bounds and solutions using different methods

Design and Analysis Products

Netonomics provides network improvement designs with superior simultaneous cost efficiency, reliability and performance as compared to designs achieved using industry legacy methods. These include:

- Core network design increasing resource utilization or resilience as cost effectively as possible, while maintaining service quality
- Access network design, enhancing resilience, lowering cost, and clustering for C-RAN topologies, meeting all technical restrictions and QoS requirements
- Analysis of traffic data, detection of long-range dependence, network impact analysis and forecasting

The Netonomics Method

The starting point is Netonomics receipt of the information described in the NetInput short data input form, in any agreed format. The service consists of pre-study, optimization, reporting to the host organisation premises during a period of a few weeks, and a follow up upon implementation of recommendations reported in the NetOutput form, showing concrete improvements in parameters compared to classical design.

About the Company

Netonomics is based on applied Teletraffic Science where each founding partner has 25 years experience in successful design, buildout, and operations of telecom and IT networks. Broad experience in decision positions has led to a focus on the essential aspects of network efficiency.