LEARN, ADAPT, AND PROTECT WITH NETANTICIPATE

Self-learning network for the zettabyte era of network traffic
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3x
More networked devices than humans on earth by 2022

5x
Increase of the average data consumption per mobile subscriber by 2024

$244 billion
Spent on 5G networks launch by the end of 2020

2x
Number of connections 2G will still handle compared to 5G by 2022
Introduction

With falling data costs and an abundance of affordable mobile devices, there has been a paradigm shift in the way we communicate. We prefer to video call or WhatsApp our loved ones over basic audio calls. We choose to share our moods with friends by posting a picture or video on Instagram rather than texting. We like to watch live football on YouTube while on the move rather than sitting at home glued to the TV.

Today’s data-hungry generation of mobile users is responsible for network traffic entering the zettabyte era. Cisco predicts that mobile data traffic will increase seven-fold by 2021, with global mobile data traffic expected to reach 49 exabytes per month and exceeding half a zettabyte annually.

To keep up with the ever-increasing volume of traffic, the network is constantly changing. It has become the bedrock of nearly every significant innovation we see around us. Network technologies are evolving at breakneck speeds – 5G, ultra-high-speed optical broadband, satellites for the advanced Internet of Things (IoT), and others – and enable us to do so much more with our networks.

IoT networks are changing how vehicles move on the road every day. Intelligent transport systems and self-driving vehicles are moving toward widespread commercialization, with higher levels of automation on the road expected by 2020. Kymeta Corporation and Intelsat are making the next evolution of the connected car a reality. They will cross-leverage each other – Intelsat’s leadership in space-based satellite communications with Kymeta’s innovative antenna technology – to bring high-speed connectivity to cars globally.

At the same time, the constantly evolving network has increased the network complexity tremendously. Communications service providers (CSPs) are gradually shifting to a software model to address the complexity at both the core and edge with software-defined networking (SDN), network function virtualization (NFV), hyper-converged infrastructure (HCI), the adoption of white-box equipment, etc. Vodafone’s virtualization project, Project Ocean, is a group-wide transformation to virtualize its network and compute infrastructure and to bring in cloud-native VNFs and network services.

Facebook has launched its Telecom Infra Project (TIP) with partners such as Deutsche Telekom of Germany, British Telecom subsidiary EE (formerly Everything Everywhere) of the United Kingdom, Globe Telecom of the Philippines, and SK Telecom of South Korea. It is an effort that resembles the Open Compute Project (OCP) that Facebook kicked off years ago but is narrowly focused on the development of new telecommunications networking hardware.

Deutsche Telekom is deploying multi-access edge compute infrastructure closer to the point of consumption to target the rapid growth in latency-sensitive applications. With simplicity comes another type of complexity. While the new network is getting simpler by design, managing the new network is getting progressively more complex. According to Pyramid Research, mobile operators are spending three times more on operational expenditures than on capital expenditures, or a total of $400 billion to $500 billion annually on operational expenditures.

It is getting increasingly difficult for humans to manage this multi-layer, multi-technology network environment while meeting stringent service level agreement (SLA) expectations to provide a high-quality user experience. Network administrators are facing a growing list of significant challenges in managing today’s networks. For instance, network congestion and failure prediction are getting increasingly difficult to manage in multi-layer networks. Security threat patterns such as distributed denial of service (DDoS) are getting harder to recognize and stop. Overlay routing optimization is difficult over an unpredictable underlay network. Network equipment power usage optimization results in huge electricity bills for service providers. Data center infrastructure failure prediction is getting increasingly difficult too. The list goes on.

Age-old rules-based network automation techniques are not working, so networks need to become intelligent so they can take care of themselves.
Architecting a brain for the network

The time has arrived for the new network to think for itself. With advances in technologies such as machine learning (ML), artificial intelligence (AI), and intent-based networking (IBN), it is now possible to build a brain for the network so that it can take care of itself.

Industry leaders are already getting their acts together to make the network more intelligent. For instance, Juniper has embarked on a journey to create a production-ready, economically feasible self-driving network that is autonomous, predictive, and adaptable to its environment.

Juniper tied its innovative Contrail platform to create a vision of a self-driving network with the release of Juniper Bots designed to translate intent into automated workflows.

Cisco has ushered in a new era of networking with its Cisco DNA (Digital Network Architecture) that constantly learns, adapts, and protects. The network is designed to be intuitive and is turning hours of work into seconds, automating processes to lower costs and using analytics to improve performance.

Similarly, Google and Amazon are using predictive algorithms to create a brain in a data center. Google is using DeepMind’s AI-based predictive algorithms. It acquired the British AI company for over $600 million in 2014 to slash the enormous electricity bill of its data centers. Amazon AWS applies ML-based predictive models to one of the toughest puzzles in data center management: capacity planning. AWS uses ML to forecast cloud data center capacity demand and to figure out where on the planet to store additional data center components so that it can expand capacity quickly where and when it is needed.

Network standardization bodies are also gearing up to explore this new area and come up with standard architectures. For instance, ETSI has created a new Industry Specification Group called Experiential Network Intelligence (ISG ENI).

The new group will define a cognitive network management architecture using AI and context-aware policies to adjust offered services based on changes in user needs, environmental conditions, and business goals. Along similar lines, the 5G Public-Private Partnership (5GPP) has established an AI project named CogNet to build an intelligent system of insights and actions for 5G network management.

These industry initiatives are helping to create a brain for the network and transform it from a dumb network that needs an army of humans to manage to a self-learning network (SLN) that self-configures, self-manages, self-heals, and self-protects with zero human intervention. SLN is a journey that began with automation and programmability and evolved through the integration and advancement of four technologies: programmability, semantic telemetry, machine decision-making, and intent-based networking.

Programmability

Automatic and programmability are the foundations of autonomous networking. Thanks to the agility and flexibility introduced by SDNs, network administrators are now able to initialize programmatically and control, change, and manage network behavior dynamically using open interfaces and abstraction of lower-level functionalities. With SDN topology discovery, path computation, path installation, bandwidth management, and other developments, the network can be fully automated. The next step is for automation to become more intelligent. For instance, bandwidth reservation is already responsive to traffic changes but can we make it smarter? Can we automate service placement and motion?

Semantic telemetry

The telemetry interface enables the collection of data from remote points to support monitoring, analysis, and visualization. But the Simple Network Management Protocol (SNMP), pull-based telemetry, and naïve deep-packet inspection are starting to show limitations. For the success of the SLN, we need telemetry that is based on push semantics and driven by network policies.

Machine decision-making

Today’s rules-based systems involve simple programming (for instance, if x happens, then do y). These rules are too rigid. ML and AI techniques will move decision-making from static programming to algorithms. AI algorithms recognize patterns in data, make predictions, and take appropriate actions without having to be programmed. The more data that is fed into training algorithms, the smarter the networks become. SLN has several advanced AI and ML models built into it to find quick and foolproof solutions for the real-world challenges faced by the network today.
Intent-based networking

Intent-based systems operate in a manner where the administrator tells the network what it needs to do, but how is determined by the network and the specific tasks are automated to make this happen. Intent-based networking allows IT organizations to move from tedious traditional processes to automated intent, making it possible to manage millions of devices in minutes. This is a crucial development to help organizations navigate today’s ever-expanding technology landscape. For example, if a business wants to secure all traffic from accounting, that command is issued, and the systems take care of all the technical details. Network changes are automated and continuous, so if a worker moves, all the policies and network settings automatically follow to the next worker. Gartner predicts that by 2020, 10% of enterprises will use intent-driven network design and operation tools, an increase from 0% today, which will reduce network outages by 65%.

These four key technology areas, combined with local and global awareness, will help build the right knowledge base for the network. Local awareness comes through continuous monitoring of the underlying network. While local awareness will remain essential, increased global awareness will usher in the SLN, featuring root cause analysis using supervised learning, time-based trending to establish and adapt baselines, correlation of information across geographies, layers, and peers, as well as optimal local decisions based on a global state.

Network artificial intelligence

Machine decision-making for SLN needs a specialized form of the AI/ML technique: network artificial intelligence (NAI). The typical machine-learning workflow has five stages: data processing, feature engineering, data modeling, performance measurement, and performance improvement, as shown in Figure 1. NAI modifies the ML workflow and its five stages and adapts them for driving SLNs.

NAI is divided into an offline process and an online process in accordance with the time aspect of data collection and analysis. The offline process refers to the existing data or non-real-time collection of data. Although the analysis process will also focus on the relationship between data and time, it does not require real-time analysis. The offline process is used mainly for two purposes:

1. Training or verification of real-time process design
2. Troubleshooting or reason analysis for events that have already occurred

The online process is the efficient real-time collection, processing, and analysis of the data to operate network monitoring and event forecasting. The main purpose of the online process is:

- Network capacity monitoring and precise optimizing
- Network event prediction and fast troubleshooting
- Real-time network optimization according to the policy
There are two data processing architectures that NAI banks on – Lambda and Kappa. The Lambda architecture is a data-processing architecture designed to handle massive quantities of data by taking advantage of both batch- and stream-processing methods. This architecture approach attempts to balance latency, throughput, and fault-tolerance by using batch processing to provide comprehensive and accurate views of the batch data, while simultaneously using real-time stream processing to provide views of online data.

Data processing and feature analysis

Data collection in networks has multiple aspects. From the time aspect, data collection can be divided into real-time and non-real-time collection. From the content aspect, it can be divided into network information (including topology, tunnels, routing, equipment configuration, etc.) and traffic collection (including network traffic, network load, device KPIs, etc.). The data collected from the network devices includes:

1. Information on the network topology
2. Routing protocol status
3. IP routes and MAC routes
4. LSP information
5. Network traffic information
6. Network configuration
7. Network device KPIs
8. Log of network elements
9. Trap of network elements
10. OAM information

Other data includes infrastructure usage information such as CPU load, memory usage, etc. All this data must be correlated in a time-series graph for performance analysis and to find patterns and trends.

Network data modeling

NAI leverages supervised, unsupervised, and reinforcement learning algorithms to create models for NAI. The applicability of an algorithm depends on the use case of the self-learning network it is being applied to. Figure 2 maps various self-learning use cases for different algorithm types.
NetAnticipate framework

The NetAnticipate framework helps CSPs build a state-of-the-art self-learning network. Its end-to-end architecture is described in Figure 3. The architecture enables the network to self-learn through continuous feedback using closed-loop automation. It uses a multi-level intent orchestrator to apply the identified intents back to the network in a simplistic way.

The batch layer is used for initial model training and model building from scratch. The speed layer is used for incremental updates of the model. A batch layer enables accurate predictions while the speed layer allows for real-time updating, which is critical to responsiveness.

NetAnticipate uses the Lambda architecture for data processing, as shown in Figure 4. It combines the best of both worlds: batch processing and stream processing. This pattern consists of several layers:

1. Batch layer: ingests and processes data on persistent storage such as HDFS and S3
2. Speed layer: ingests and processes streaming data that has not been processed by the batch layer yet
3. Serving layer: combines outputs from the batch and speed layers to present merged results

NetAnticipate brings immense value to customers in five important ways:

1. Enhanced end-user experience and reduced customer churn through proactive detection of network issues and by meeting dynamic customer needs
2. Higher operational efficiency by simplifying network operations and facilitating a consistent, error-free network
3. Guaranteed SLAs to avoid the financial impact of SLA penalties and improve brand reputation
4. Improved employee productivity by freeing up expert resources from day-to-day tasks such as debugging and root cause analysis
5. Reliance on trusted and proven telecom expertise to minimize the risk of inadequate solution capabilities and to gain a competitive advantage.

We take a staged approach to achieve a fully autonomous network, as shown in Figure 5. The journey toward the autonomous network will be challenging but the rewards will unfold in real time. The most important decision is to take the first step.

Figure 3: the Capgemini Engineering SLN architecture

Figure 4: SLN data processing architecture

Figure 5: Capgemini Engineering staged approach for the autonomous network
Conclusion

Network traffic has entered the zettabyte era, making it impossible for humans to analyze the huge volume of data within seconds to make real-time decisions. Traditional tools also do not have the power to analyze heterogeneous data at ultra-high speeds. So, the time has arrived to architect the brain of the network so that it can self-configure, self-manage, self-heal, and self-protect with zero human intervention.

This self-learning network stands on five technology pillars: automation, programmability, semantic telemetry, machine decision-making, and intent-based networking. We reviewed the challenges of building such a self-learning network and discovered that general-purpose AI is not suitable. A new type of AI – Network Artificial Intelligence (NAI) – has to be built that leverages both online and offline processes for accurate predictions and responsiveness. The Lambda and Kappa data processing architectures are most suitable for NAI. Therefore, the Capgemini Engineering NetAnticipate framework, with its constituent components, will help you understand and realize the self-learning network in a service provider environment.

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