iot
enterprise
insights

Artificial Intelligence and Machine Learning

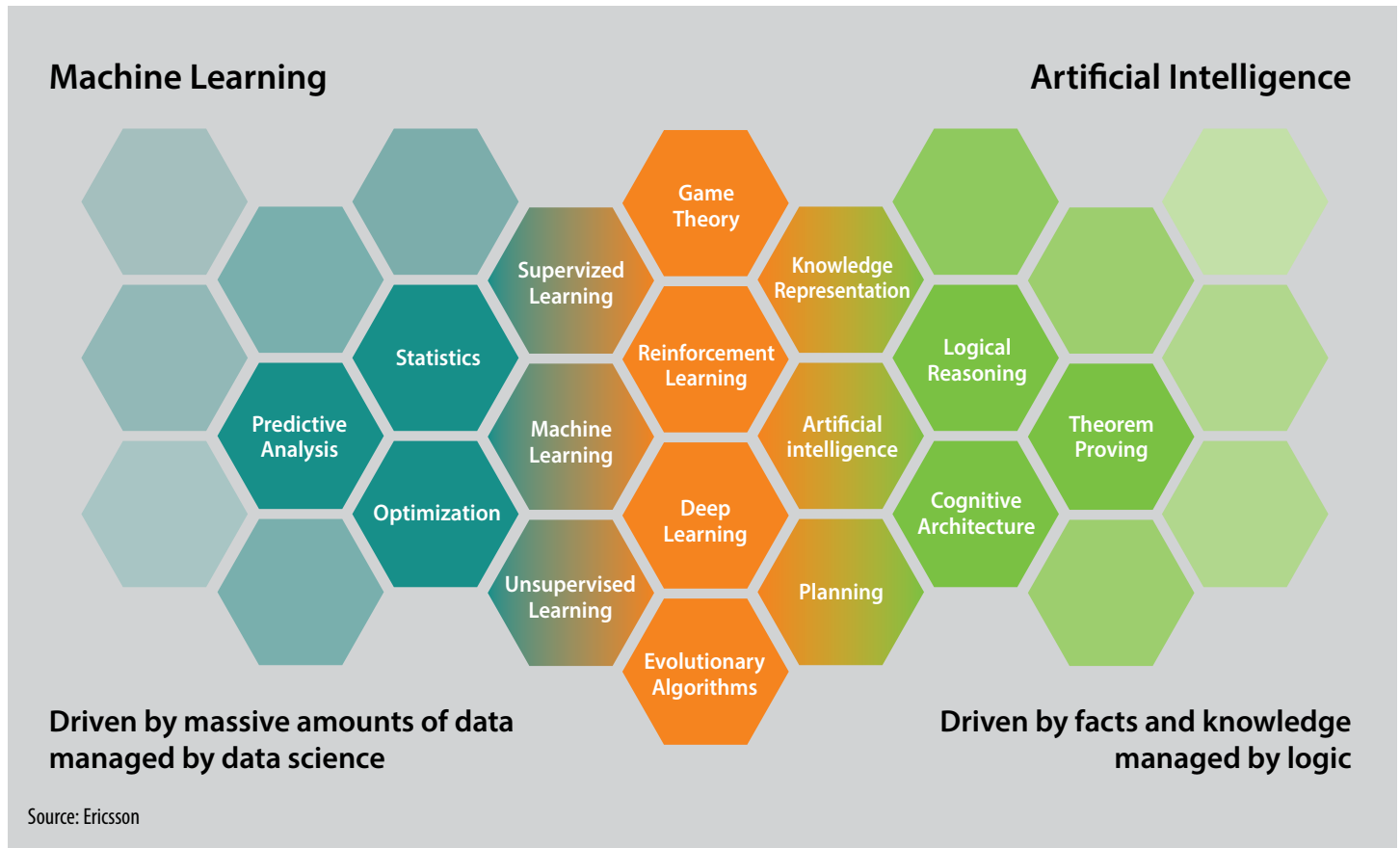## *Making IoT work for telecoms*

by James Blackman

Machine Learning

Artificial Intelligence

Game Theory

Supervized Learning

Knowledge Representation

Statistics

Reinforcement Learning

Logical Reasoning

Predictive Analysis

Machine Learning

Artificial intelligence

Theorem Proving

Optimization

Deep Learning

Cognitive Architecture

Unsupervised Learning

Planning

Evolutionary Algorithms

Driven by massive amounts of data managed by data science

Driven by facts and knowledge managed by logic

Source: Ericsson

Today's wireless networks are hugely complex already, and will acquire new layers of sophistication as the industry launches 5G services. Traditional rule-based, deterministic algorithms no longer cut it.

Network operators require more dynamic methods to get the best from their infrastructure and services.

Artificial intelligence (AI) and machine learning (ML) afford traditional telecoms providers a rare opportunity to reinvent themselves for the new digital age.

Having been the preserve of mathematicians and sci-fi writers for 70 years, since Alan Turing showed digital computers could simulate formal reasoning, the field of AI appears to be coming of age at last in practical terms. Its application, as 'weak' or 'narrow' AI, has been spurred in commercial enterprise by advances in cloud computing and ML techniques.

The telecoms industry is heavily invested in its development. "The telecoms network is the basis for the outbreak of AI, and AI will greatly enhance the telecoms network," comments Zhang Sihong, chief engineer of AI solutions at ZTE.

AI was the talk of the town, again, at Mobile World Congress (MWC) in Barcelona in late February, invariably as a means to manage the rising chaos being unleashed by a new generation of LTE-based technologies. Narrow AI – as opposed to

"The telecoms network is the basis for the outbreak of AI, and AI will greatly enhance the telecoms network."

Zhang Sihong, chief engineer of AI solutions, ZTE

'general' or 'strong' AI, describing a higher state of machine consciousness – and its complementary disciplines in the ML field have now passed 'peak hype', reckons Gartner in its latest 'hype cycle' of emerging tech trends.

Doron Youngerwood, product marketing manager for big data and AI at Isareli software developer Amdocs, reckons the practice will become standardised in network operations in the coming months. "Although it has been around for a number of years, it's only in past year been this huge excitement has grown up around it. And the hype is not just noise," he says.

"This year, AI will become mainstream among operators, who stand to benefit from it more than any other industry – more than manufacturing, banking, retail, anything – because they are sitting on this goldmine of data. With sensors and IoT devices, it is only getting bigger, and they need a way to make sense of it all."

First mistake | Distinguishing AI from analytics and automation

I t is worth pausing, early, to consider the terminology itself. The classifications, 'narrow' and 'general', distinguish a more limited branch of AI, as practiced in the tech sector today, from the more far-out view of sentient machines, as considered by scientists in academic papers.

"The purists would argue none of the technologies presented as AI by telecoms practitioners is the real deal," remarks Dimitris Mavrakis, research director at ABI Research. "Most stuff in telecoms is not really AI, in the traditional sense. This idea of self-aware machines won't be realistic for 1,000 years."

In narrower terms, AI presents the idea of intelligent machines, able to perform certain tasks with human-like knowledge; ML is the means to achieve this higher machine-state. Ericsson unites them under a single banner, as 'machine intelligence'; the pair combines, it notes, "to create data driven, intelligent, robust systems for

"AI does not mean big data and analytics – they are inputs into an intelligent system, but they are not AI, and they're not what operators need, actually."

Jay Perrett, chief technology officer, Aria Networks

automation, evolution and disruption".

Ericsson has a cake analogy; it used to be you reached for the flour, sugar, and eggs, explains Peter Laurin, the company's head of managed services, at a press gathering at MWC. "You used to hire engineers to run scripts… Now, if you want a chocolate cake, the computer mixes it for you." It also learns how you like it for taste and texture, he says.

But these disciplines diverge as well, serving different ends. ML feeds on data, in huge volumes, driving out patterns and deviations. AI is governed by facts, knowledge, and logic. The commercial outputs are different. Ericsson's applied analytics, underpinned by AI and ML techniques, informs its product set; learned automation, underpinned by the

same, stimulates its services offer.

There is a trap, however. The conflation of ML and AI with high-grade analytics and automation is wrong. AI can help to achieve the perfect bake, regardless of the quality of the larder or equipment. It should save the baker time and money as well. "AI does not mean big data and analytics. They are inputs into an intelligent system, but they are not AI – and they're not what operators need, actually," remarks Jay Perrett, founder and chief technology officer at Aria Networks.

He dislikes the confusion: analytics is way to make correlations and automation is the final action in a sequence; AI is the human-like intuition that links the two - more than just making insights actionable, it decides a course of action. In networking, it is a tool to improve the way services are delivered in a dynamic environment, where margins are constrained. Every aspect of network operations, from design through to management, will be touched by AI and ML, he says.

"Not because it's clever, but because it's necessary." The explosion of IoT endpoints on network systems makes it so.

Telefónica sums it up effectively. "There is no future for operators without taking advantage of data through AI, including ML and big data technologies," says Francisco José Montalvo, director of the Spanish firm's 'fourth platform' division, established in 2017 to orchestrate its underlying data functions. AI will make its operations efficient, and its relationships tight, he says.

Great promise | Orchestrating the rising chaos of IoT networks

F or telecoms providers, the need to automate is urgent. "The amount of data is about to explode," comments Mavrakis. The notion they will gain control just by re-defining their networks in software is wrong-headed, he says.

Barcelona - AI was the talk of the town at MWC 2018, as a way to manage the data explosion in 5G networks.

"It is supposed to get simpler with software-defined networking (SDN) and network-functions virtualization (NFV); it won't. It will get more and more complicated. It just becomes virtualized chaos."

Even just on the radio-access side, the picture looks gnarly. The number of parameters per base station has jumped from 500-odd in the 2G era to 1,500 with 3G, and closer 3,500 with 4G, notes Ericsson. LTE has introduced some automation tools to allow network managers to auto-tune these settings, but more is required. "We have to do better," comments Ulrika Jägare, director of analytics and machine intelligence at Ericsson.

Ericsson has a fruit analogy, this time, based on the idea bigger data and deeper analytics afford brighter insights. The sector's traditional performance metrics, around such things as dropped calls and service availability, don't cut it anymore, says Laurin. "It's like a watermelon – all my KPIs show green, but on the inside everything's red, and my customers are not happy," he says, referencing a recent conversation with a client.

"We are moving from a quantifiable environment, which is very smartphone centric, to one that adds great complexity

"It is supposed to get simpler with SDN and NFV; it won't. It will get more and more complicated. It just becomes virtualized chaos."

Dimitris Mavrakis, research director, ABI Research

with 5G and IoT. The number of devices on the network will quadruple in the years to come; the complexity is increasing, the number of alarms is increasing. We see that already. That's a challenge for the operator, and an opportunity for us."

The human brain will be over-whelmed, says Adaora Okeleke, senior analyst at Ovum. "Humans can't handle the volume of data and insights that will be coming out of the networks. We need AI to harness all this information – to see the patterns in the data, and to inform the activities."

Indeed, it is a potential boon for vendors, shifting away from generational kit sales to service-based models. "As 5G brings along new levels of efficiency and at the

same time complexity, AI is in a key role to enable 'living' networks that adapt to constantly fluctuating conditions," says Andrew Burrell, head of marketing for ultra broadband and analytics services at Nokia, referencing also Nokia's Future X architecture, which embeds AI in all layers of the network, including the access part.

AI promises to bring logic and order to the incoming chaos, and, with the arrival of 5G networks, a way for operators to harness the whirlwind, reckons Sihong at ZTE. "AI will empower 5G, and 5G will enable AI to play a greater role in the field of networking," he says.

However narrow its definition, the commercial application of AI brings higher intelligence to network management. It appears like a panacea for managing infinitely complex network operations. "There is a need for automation to translate a simple click from a user into everything a network does in response, without human intervention," says Mavrakis.

And therein likes the magic of AI, and the basis of the hype: orchestration of unknowably complex communications systems. But how much is live theatre and how much is controlled rehearsal – and how are the early reviews?

Early progress | NLP in chat-bots in customer care channels

The vendor community is enthusiastic, of course. "It's not a nice-to-have anymore; it's a must-have. This is bread-and-butter for us, today. There is no sci-fi about it – it is here and now." Ericsson has been researching the field for a decade already, adds Laurin; it has patents coming out of its ears. "I don't know how many, but there's a significant amount of IPR in Ericsson now."

Nokia is staking its future on AI in the same way, integrating related techniques

Applications of AI in telecoms

	Analysis	Automation
Business	Margin analysis Demand forecasting	Multi-domain service design Capacity optimization
Network	Fault prediction models Root cause analysis Wost-case failures Capacity predictions Anomaly detection	Policy-based route design Robotic process automation Self-healing networks
Customer	Churn prediction Fraud detection	Chat-bots Proactive marketing

■ Big data	■ Business modelling	■ Natural language processing	■ Mechanization	■ Simulation

Source: Aria Networks

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into every aspect of its portfolio. It uses a range of open source and proprietary machine learning algorithms, mostly developed in co-operation with Nokia Bell Labs, plus its own as well, related to video analytics and image recognition. It has partners for speech recognition and natural language processing (NLP).

Telecoms providers are learning fast, reckons Burrell. "Increasingly, both business and operational use cases are including AI," he says. Its application in telecoms networks is already broad, and getting broader, he says. Examples run the gamut of functions from autonomous care, predictive churn analytics, and contextual engagement in sales and marketing, through to maintenance and troubleshooting, and design and optimization techniques in network operations.

Others are circumspect. The market is still developing its routine. "The work has been exploratory so far," comments Okeleke at Ovum. Is anyone, among global operators, doing particularly well? Not really, she implies, although AT&T in North America and Vodafone in Europe are described as "most active".

This is the consensus, in fact. The operator community, at large, is only just getting to grips with the practical implications of AI. "They are curious about it, but they're struggling to understand how to apply it," comments Jägare at Ericsson. Discussions are picking up, she says, but they are still moving too slowly.

"The solutions coming out are more related to analysis of user perception, churn predictions, and marketing campaigns. On the network operations side, they want to understand – they're interested in taking those steps, but they're not driving it themselves. They're looking to us, as a vendor, to know what they should be doing, and what could be helpful. They want ideas from us."

Okeleke notes also the sector's fluffier desires around brand 'experience' have taken flight more easily. "Most activity has been around the customer experience, and improving efficiencies," she says. "It's very early – there is a lot of work just to

"It's not a nice-to-have anymore; it's a must-have. This is bread-and-butter for us, today. There is no sci-fi about it – it is here and now."

Peter Laurin, head of managed services, Ericsson

understand the value of it."

The categorization of AI in telecoms can be cut any number of ways. Positive Technologies describes four buckets of usage: as consumer analysis, networks management, diagnostics and troubleshooting, and information security. "It can be applied for many other business areas as well," remarks Dmitry Kurbatov, the company's head of telecommunications security. "The number of activities that can be optimized is enormous and promising."

Telefónica identifies four business needs as well: in business optimization, market insights, customer engagement, and business innovation. Aria Networks describes three: in customer-facing applications, for churn and fraud prediction; in network-facing applications, for predicting faults, failures and breaches; and in business-focused applications, for margin analysis and demand forecasting.

What is clear is the majority of applications are customer-facing, rather than network-facing.

Business logic | 'Serious' money in AI savings and investments

So far, the telecoms industry has made the most progress with AI in customer-facing applications, invariably linked with care, marketing, and sales functions. "It is easier in these customer-facing functions to close the loop – to let a machine handle everything," notes Mavrakis at ABI Research. Critical infrastructure is not in play – just easily categorized lines of communications with customers.

In particular, he points to the use of natural language processing (NLP) in customer-facing chat-bots, where auditory and textual synthesis gives the impression human representatives are online. "That is the most popular use case for AI."

Mavrakis lists the usual suspects among tier-one brands, in no particular order: "Orange, China Mobile, SK Telecom, Deutsche Telekom, Vodafone, Telefónica – they're all using chat-bots," he says.

Some claim to be solving up to 60 per-cent of customer enquiries without human intervention, he suggests. But there is little in the way of recorded uplift beyond the resolution of calls to automated care lines. "We can't yet say what effect there has been," he says. What can be measured, he suggests, as a snapshot of the vital power of AI to telecoms providers, is their rate of investment in the field.

As a rule of thumb, tier-one operators invest one per cent of annual revenue in internal research and development (R&D) projects, many of which will link to AI any-way. Besides this, the top 20 brands in the world spent around $3 billion in 2016 and $5 billion in 2017 on external investments and acquisitions in AI pioneers, calculates ABI Research. The figure will rise to $9 bil-lion in 2018. "It is a high level comparison," says Mavrakis. "But they are dropping seri-ous money into it."

Orange is more explicit about the improvements it has achieved. The mar-riage of big data and AI is a "huge" affair, it declares. "The gains from mixing these are significant at a group level," says Luc Bretones, executive vice president of the France-based group's Technocentre and Orange Fab businesses, established as pipelines for new services and start-ups, respectively, and both focused on self-ful-filling innovation in fields such as AI.

Its net-promoter score (NPS) for apps inte-grated with some self-service functionality, even where final actions are taken by humans, is up by "10-20 points", it reckons. In general, the company is strong in data analytics – be-cause its "research forces have invented a state-of-the-art algorithm", which informs most of its marketing, sales, and operations.

Orange has 150 AI-related initiatives in development, in total, scattered across 30 markets. "What we want to do is to auto-mate processes. We want to make savings on the basis of big data and analytics," says Bretones. It's a kind of Darwinian selection, he says, where the best will be implement-ed across its footprint.

The cream rises to the top, and spreads across its markets. "Poland is very efficient in terms of network investment, Romania is very efficient in terms of sales. We try to share best practices." The example of after-sales automation, raising NPS, origi-nated in France, as a service for small and medium-sized enterprises; it automates most standard network options, from up-grades and roaming to PUK code activa-tion. "The back office is becoming the front office," comments Bretones.

"Most of the activity has been around the customer experience. It is very early – there is a lot of work just to understand the value of it."

*Adaora Okeleke, senior analyst, Ovum*

Every-man AI | The back office becomes the front office, for all

At the same time, Orange and Deutsche Telekom have jointly-developed an AI-based voice as-sistant, which goes by the name Djingo in France and Magenta in Germany. "We divided the development in two. It has been unique collaboration in Europe."

Djingo started as a feature of its TV app in France; the transition to the wider world has been somewhat complicated. Bretones says the trick with any NLP-based learning is time and effort; context is one thing, language

Operators' investments in AI

The total annual investment of the top 20 operators in the world in external investments and acquisitions in AI-related enterprises

$9bn

$5bn

$3bn

2016   2017   2018
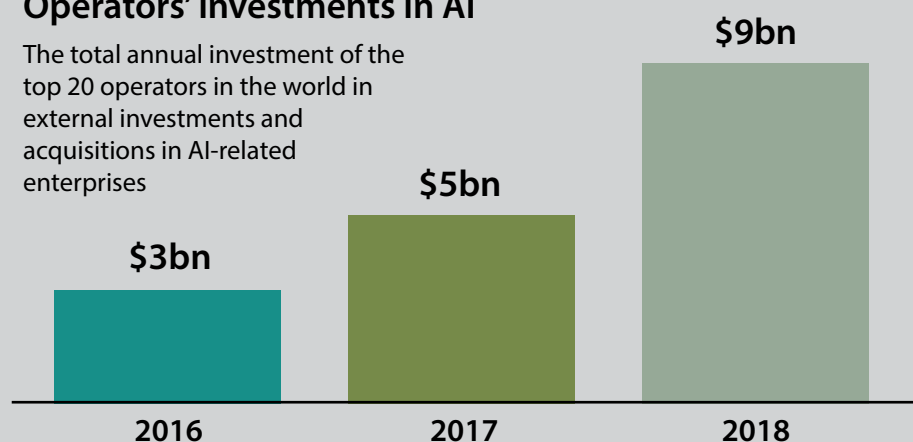
Source: ABI Research

Easy - French telco Orange talks through its digital voice assistant, Djingo (bottom, center), at a recent showcase; NLP technology has its challenges, but is now well understood.

is another, even in the same country. "If you're in Marseille in the south, or Lille in the north, the differences are really quite pronounced. It's natural enough for a French guy, but for AI it's anything but trivial," he says.

Telefónica has debuted a consumer-facing AI assistant as well, called Aura. Its AI and ML programs are hinged on large volumes of data, it notes; its cognitive computing is built on Python and Scala for Apache Spark based ML libraries, and make use of mainstream models and approaches, such as clustering, regression, and classification. The Spanish group is using steadily more advanced deep learning and reinforcement learning technologies, says Montalvo.

Aura is the company's headline act; the service will exist as a branded app in Argentina, Brazil and the UK, as part of the company's pay-TV platform in Spain, and via Facebook Messenger in Chile and Germany. It will be integrated with Google's Assistant and Microsoft's Cortana in 2019.

> "The way the industry is using AI from a front-office point of view is completely the same as finance or insurance. It's not interesting from a telecoms point of view – it's only when you get into the way this business works it gets interesting."

Robert Curran, marketing director, Aria Networks

"In terms of marketing and customer relationship, Aura will gain more and more relevance, becoming the cornerstone that will support a radical transformation in the way in which our customers will interact with us, moving towards a really AI-based personalized relationship," says Montalvo.

But chat-bots are relatively easy, as Orange set out to demonstrate at MWC by showing the simple set-up of text and voice interfaces equipped with NLP savvy. They are everywhere too, of course; the telecoms industry is hardly first to the punch. "The way the industry is using AI from a front-office point of view is completely the same as finance or insurance," remarks Robert Curran, marketing director at Aria Networks. "it's not interesting from a telecoms point of view – it's only when you get into the way this business works that it gets more interesting."

Besides the application of NLP and automation in care scenarios, or in Echo-style hockey pucks, the contemporary telecoms version of AI is also deeply ingrained in sales and retention, designed to analyze usage patterns and customer segments to direct promotional activity and head-off technical issues. "We have been able to improve the performance of traditional business intelligence models to predict

churn, generate product recommendations, and reduce our risk in commercial operations," comments Montalvo.

Most operators are moving away from traditional customer segmentation models towards laser-focused personalisation, executed at scale, notes Youngerwood at Amdocs. "It's broader than just chat-bots," he says. "It's everything related to the customer experience."

The Amdocs Engage platform has become a default choice for network operators to enlighten marketing activities, he suggests, although public deals are scarce. "It enables operators to treat each and every customer individually, to provide each of them with a personalised contextual and proactive customer experience," says Youngerwood.

The Engage platform creates a dynamic profile of every customer profile, which flexes with live data inputs. "Many traditional segmentation models are outdated, and can't keep up with frequent changes and real time events," he says. Its trick is to neatly combine data from between 25 and 60 systems. "How do you bring that together? To create a single source? You can't do it manually."

The Amdocs solutions uses ML to extract data from these systems to provide a live tracker of key metrics, from risk of churn to propensity to purchase, and to automate a response, invariably as one-off promotions to drive loyalty. Youngerwood

says one unnamed UK-based operator has boosted total revenue by five per cent since deploying the platform; another in Chile has reduced churn by at least 20 percent.

Telecoms focus | The nitty gritty of network-oriented AI applications

These make clear the commercial advantage of high intelligence. There is a perfect logic to the industry's pattern of deployment with AI. "First you try to sell more, then you try to optimize your costs," says Kurbatov at Positive Technologies. "The most common usage lies in the areas of sales and marketing – to analyze and understand customers, to predict their requirements, and pre-empt difficulties."

Network-focused tasks like diagnostics and troubleshooting, and management and optimization are like "supporting activities", he says, at least until the sales operation is swinging. Information security is another, although operators are finding some success monetizing security. Gartner reckons 20.4 billion connected 'things' will be in use by 2020, up from 8.4 billion in 2017. Cisco says the market's value will outrun US GDP by 2025, reaching $19 trillion. But it is not just toothbrushes and teddy bears

Azvine - BT is using AI and ML to underpin cyber-security.

connecting to the internet, notes Kurbatov. "We're not the only ones delivering cutting-edge of technology – hackers are innovating too," he says.

AI-driven security can be a point of difference, he notes. "Quality is not limited just to speed, latency, and availability – in many areas, it also includes security."

Ben Azvine, head of security futures at BT, says the UK-based telecoms provider's security division is one of its fastest-growing. The company is using analytics and AI to augment its cyber security capabilities – the former to consolidate large amounts of structured and unstructured data from across its network to show trends and patterns, and the latter to automate a "holistic view of the global threat environment". In parllel, it uses deep learning to train a neural network to learn normal behaviour and derive anomalies, and visual analytics to

"Many traditional segmentation models are outdated, and can't keep up with frequent changes and real-time events."

Doron Youngerwood, product marketing director for big data and AI, Amdocs

present the results for human verification and further investigation.

"We are looking to enhance human detection capability, rather than completely automate the detection process," explains Azvine, In cyber security, AI can play an important role in automating many of the manual processes that people often bypass such as patching, updating anti-virus, and configuring firewalls, he notes.

"Our research is looking at reducing the training time and understanding types of data that can be used to train the neural network. We are also looking to enhance the security of AI systems and the data they use by developing advanced encryption technologies. The result will lead to deeper and broader application of ML."

It is the only way for it to cope with the growing number of threats in the IoT space, it suggests, by automating filtering of high-volume low-impact attacks to put focus on unfamiliar sorties from left-field. "It is the needle-in-the-haystack problem," says Azvine.
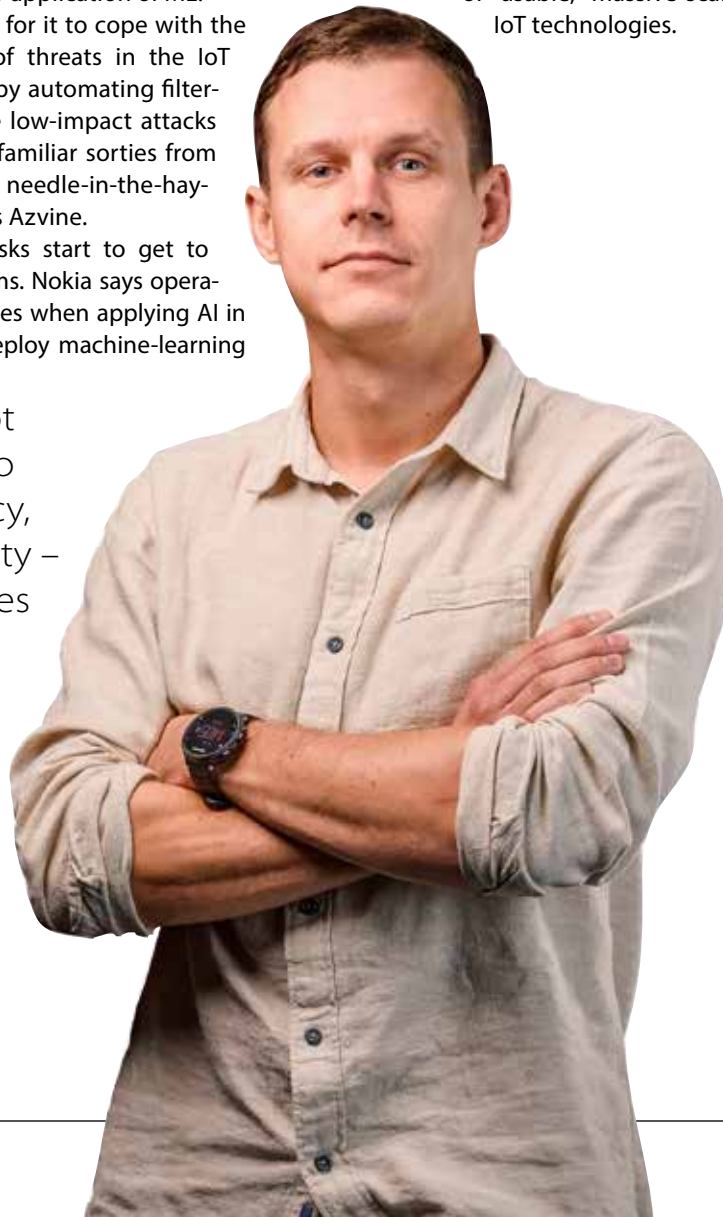
These parallel tasks start to get to the heart of telecoms. Nokia says operators have two choices when applying AI in their systems: to deploy machine-learning

> "Quality is not limited just to speed, latency, and availability – it also includes security."
>
> **Dmitry Kurbatov,
> head of telecoms
> security,
> Positive
> Technologies**

models at the core of their networks, invariably in the data center, or at the edge, in the operations center or the base station. It draws the distinction: most customer-facing use cases, in experience management, churn analytics, and care functions, retain AI at the core, as they need to compile a centralized view of the data; applications that seek to bring intelligence to network operations rather deploy AI at the edge of the network.

This last part is linked at the deepest level with the nitty-gritty of essential infrastructure, and promises to deliver the most dramatic transformation, impacting every department. It is looks to be the real climax in the magic show, and a key to the future of usable, massive-scale IoT technologies.

Trouble shooting | Self-learning algorithms in RAN base stations

Network maintenance and design is getting smarter, notes Telefónica. "We are completely reviewing our network planning model to optimize our cap-ex efforts through AI and ML processes, being able to achieve significant cost efficiencies in one of our most relevant budget items."

Research house IHS Markit presents three AI functions of self-organizing networks: self configuration, self-optimization, and self-healing (see box). Luca de Ambroggi, senior research and analyst director at the firm, says AI takes a variety of forms in these technical functions, from stochastic algorithms down to neural networks, and deep learning. "Breaking this down today is tough, because we are just at the beginning. My gut feeling is the industry is far from settling on a few winning technologies. Different solutions have different advantages," he says, making reference to programmability, implementation, and cost. "All the above flavors will probably end up in different techn choices," he says.

There are tangible gains from edge intelligence already, claim vendors. Nokia regards the application of AI in network operations as "low-hanging fruit", with the greatest application and impact in the shorter term. It has plenty of reference cases, it seems. One European operator has seen a "20-40 per cent increase in troubleshooting effectiveness" since Nokia let a particular Bell Labs algorithm loose in its systems.

Another tier-one brand, this time in the US, is correlating data from network and care functions using ML to separate devices with degraded service from devices without; it is predicting 70 per cent of network incidents before they happen. There are more examples: Qatari-based Ooredoo has seen a 50 per cent jump in LTE speeds by future-mapping

coverage, congestion and interference; an Asian operator has eliminated 35 per cent of dropped calls by crowd-sourcing data from customers' devices.

Ericsson describes troubleshooting a 4G launch in the US in 2017: engineers at the coalface were going through 16-page manuals to fix a rush of issues in the transmission network, it recalls.

"The customer had about 800 alarms per week, and the alarms were taking 60 minutes to fix." The company set an AI program to work: its automation tools diagnosed the faults, its data scientists selected the course of action, and the program automated the fix. Repair times fell 20-fold, to just three minutes; the manual workload was reduced by over 700 hours per week, it says.

In tandem, it has developed a 'digital twin' application, called Intelligent Site ('In-Site'), which draws on internal and external data streams to provide a give view of live base stations in the network. It applies AI and ML algorithms to detect deviations and patterns, draw insights, and trigger a response. "Our automation platform executes a preventive or resolution action back into the network. The result from the action is then fed back into the algorithms for continuous learning," says Jägare.

Ericsson has put self-learning algorithms in its base stations to assist also with energy management and load balancing. In the first, they are set to understand the traffic conditions of the site, and trigger sleep mode during dead time. In the second, they optimize the load between different frequency bands. In both, the algorithms flex to accommodate live traffic data.
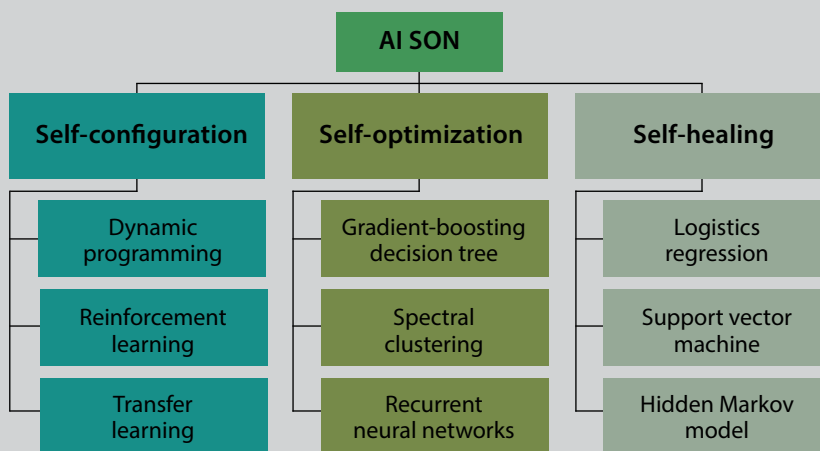
"These are just two early examples; it shows what we can do," remarks Jägare. Vodafone Spain has been using both Ericsson and Huawei in trial since April 2017 to reduce incidents and improve fault management by ensuring the system automatically chooses the best frequency or node for each connection. It expects to embed the mechanisms across its base stations in Spain this year. Ericsson says its solution worked better than Huawei's.

At MWC, Ericsson also showed ML

Optimization - Ericsson and Softbank have completed an AI pilot on 260 base stations, set to roll-out nationwide.

Applications of AI in telecoms

AI SON		
Self-configuration	**Self-optimization**	**Self-healing**
Dynamic programming	Gradient-boosting decision tree	Logistics regression
Reinforcement learning	Spectral clustering	Support vector machine
Transfer learning	Recurrent neural networks	Hidden Markov model

Source: IHS Markit

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techniques to configure and design Softbank's LTE access network in 'dense urban clusters' in Tokai, in Japan. "Softbank came to us and said, 'we have an optimized network, but you give it a shot - we heard about your AI and ML; give it a shot'," explains Laurin. The solution considers multiband complexity, as well as "future design requirements", according to Jägare. "The design process was completely automated and big data analytics applied," she says.

In the pilot, Ericsson analyzed a total of 4.3 million permutations from a cluster of 260 sites for the best 'centralized' and 'elastic' RAN combination. It delivered remarkable gains compared with a traditional design, including 40 per cent improvement for lead-times, 45 per cent for carrier aggregation, and 94 per cent for cell throughput. The service is being rolled out by Softbank and other operators in the region.

Embryonic phase | The long tail of AI proofs and references

But the subtext to the MWC narrative, where so much AI was on show, made clear its application is embryonic in networking, in telecoms at least. Ericsson pointed the way for self-learning in the core network, for example, with the deployment of a virtualized self-learning agent, delivered as a service, which automates VNF auto-scaling to optimize system usage and energy efficiency. Results from lab trials suggest ML can deliver a 25 per cent jump within two weeks of deployment.

The continuing

shift towards service-based infrastructure provision was another theme. "We're not selling a big platform. Our customers want to buy small things, capabilities, which solve problems directly – which don't require teaching. The intelligence is built into the algorithms, and the output is delivered to them in the format they want," says Jägare.

They are passing down the intelligence, for re-sale under the same terms, as well. Nokia announced a sensing-as-a-service solution, which renders insights from environmental data for operators to sell to city and city-related authorities; the application might be used to detect environmental behavior and anomalies, like illegal construction, trash burning, or pollutants, it says.

But there remains a long tail of proofs and references, served up to establish the technology in the first place. "We are at the beginning. Today, we have extracted just a teeny percentage of what we can do. We are at 10 per cent of extraction. We have 90 per cent to go. The potential is huge," comments Bretones at Orange, making the general point at the same time that analytics and automation should not just be agenda items in 5G focus groups, but fiercely e m b r a c e d today in live operations. " E v e n

crappy processes can be optimized – you might not solve the basic efficiency issues, but they will be more effective. The virtualization, or 'software-ization', of network features is something that has to be dealt with in parallel," he says. This is an important point, of course. While many of the bigger-ticket acts, in self-organizing and self-optimizing networks, are still being worked out in the practice room, there remains a lively stage show off-Broadway for right-minded audiences.

Like everyone, Orange talked about future networks as 'all-knowing', 'expandable', and 'optimal' at MWC, by virtue of the fact they will be neural, heterogeneous, and self-organizing, and able to predict and flex to dynamic traffic demands in a heartbeat.

Telefónica says the coexistence of legacy and future technologies, and broad-based IoT heterogeneity, will limit traditional planning and operation techniques. "We'll probably pass the point where humans can design and manage this new network. The combination of NFV and AI will lead to the evolution of automatic, self-optimizing, self-healing networks, complemented by high performance computing power and data analytics capability. We are starting to work towards this goal," says Montalvo.

Okeleke at Ovum notes the extant requirement for operators to manage physical and virtualized networks in tandem. "In the end, there will be a combination of both; vendors need to come up with ways to

"We're not selling a big platform; our customers want capabilities that solve problems – which don't require teaching. The intelligence is built into the algorithms, and the output is delivered as they want."

Ulrika Jägare, director of analytics and machine intelligence, Ericsson

manage these environments concurrently," she says. This is the effect Aria Networks is going for with its simulation technique, which creates or recreates multi-vendor network topographies, covering sundry internal and external inputs right down to power tariffs in the data center.

It goes further, it reckons, than vendor-style 'digital twin' offerings. Operators can run complex load-balancing scenarios through the system to make the best of their equipment, and re-design and re-build as necessary. "We've demonstrated how operators can deliver complex business services more quickly. We've also been able to defer future cap-ex by using existing capacity in a more efficient way. And we've shown how operators can create new value by giving customers more options for optimizing their services, for example for latency as well as cost," says Perrett.

The company's biggest competitor is Microsoft Excel, he jokes; operators typically run analysis of new deployments on spreadsheets, which provide a workman-like tool for simplistic schematics of to smaller networks. "It's fine when you don't have a decision to make in seconds. But what are your options when you have a complex decision, a what-if scenario, which needs to be resolved very fast? You can change the network quickly because of SDN and NFV – the part that's missing is how to do it."

Self-organizing | Simulatory design and closed-loop automation

The point is the carrier community is obliged with 5G and IoT to be more agile, and to marry AI and ML techniques in its continuing migration to software-definability. "Efforts are still at quite an early stage but can represent a real breakthrough – especially as we look towards billions of connected devices constantly needing

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Luc Bretones, executive vice president of Orange's Technocentre and Orange Fab

"We'll pass the point where humans can manage the network. NFV and AI will lead to automatic self-optimizing, self-healing networks, complemented by high performance computing and analytics."

Francisco José Montalvo, director of 'fourth platform' division, Telefónica

changes to the network," says Perrett.

His company is working with an operator in the Asia-Pacific region, using machine learning to train a neural network to predict the service quality of DSL lines, given certain known parameters about them. The big data begets the insights, he comments, but what then? He returns to the early discussion of semantics. "That's the analytics part. What do you do with that information once you have it? That's the AI part."

Prioritizing and automating fiber upgrades

could be one simple result, he suggests; intelligent management of troubleshooting might be another. "But these are small extensions to the analytics function. The big extension is how to change the way the network operates." Different pathways and splitters could improve the transport network without the cap-ex pressure of physical upgrades. "It's about engineering the system to give the best service I can with the constraints I have."

Instead of long cycles of planning and

assessing the impact of future changes, operations can see immediately the future state of the network, including where services are constrained and capacity is over-provisioned. These gains will filter down to other departments; unused capacity, identified by AI, might be re-positioned and presented by sales and marketing, he suggests.

The Asia-Pacific project went from raw data to a supreme accuracy in about a week, reckons Curran. "In AI generally, the process of training a neural network is really complex, volatile, time-consuming and difficult to get right – our use of 'AI to make AI' is pretty revolutionary," he says. "The point is to show the sort of applications that are possible, and that not every application of AI requires a data lake and a year of tweaking models."

Indeed, Aria Networks says it can project network design scenarios even without myriad data inputs sparking across a live network. While analytics engines cannot run without a full tank of data, AI functions just fine. "Just because you can't use analytics doesn't mean you can't use AI," says Curran. "If you can simulate the network, then you can use AI, even in the absence of data."

He explains: "I don't have to build a network and wait to see what happens, and then churn around afterwards to see how wrong I was. You can do all of that up-front." The company has been engaged on just such a simulation with Facebook, which wants a high-grade network to connect its six largest data centers. "If it had built according to it own analysis, it would have spent 33 per cent more than it needed to," comments Perrett.

While SDN and NFV, on the coattails of 5G, will enable operators to define and deploy new capacity and services in software in moments, this great flexibility brings great risk. "Imagine how fast you will be able to build networks – in just minutes. Now, imagine how quickly you will be able to make blunders – if they are not designed in the right way."

Forget fundamental design flaws, he is saying; the cost will quickly add up if operators fail to fine-tune their networks across rapid-fire deployments. "If they don't use this ability to assess what's going on and change their networks to benefit them – not in terms of throughput, but in terms of margins – then they will lose out. "
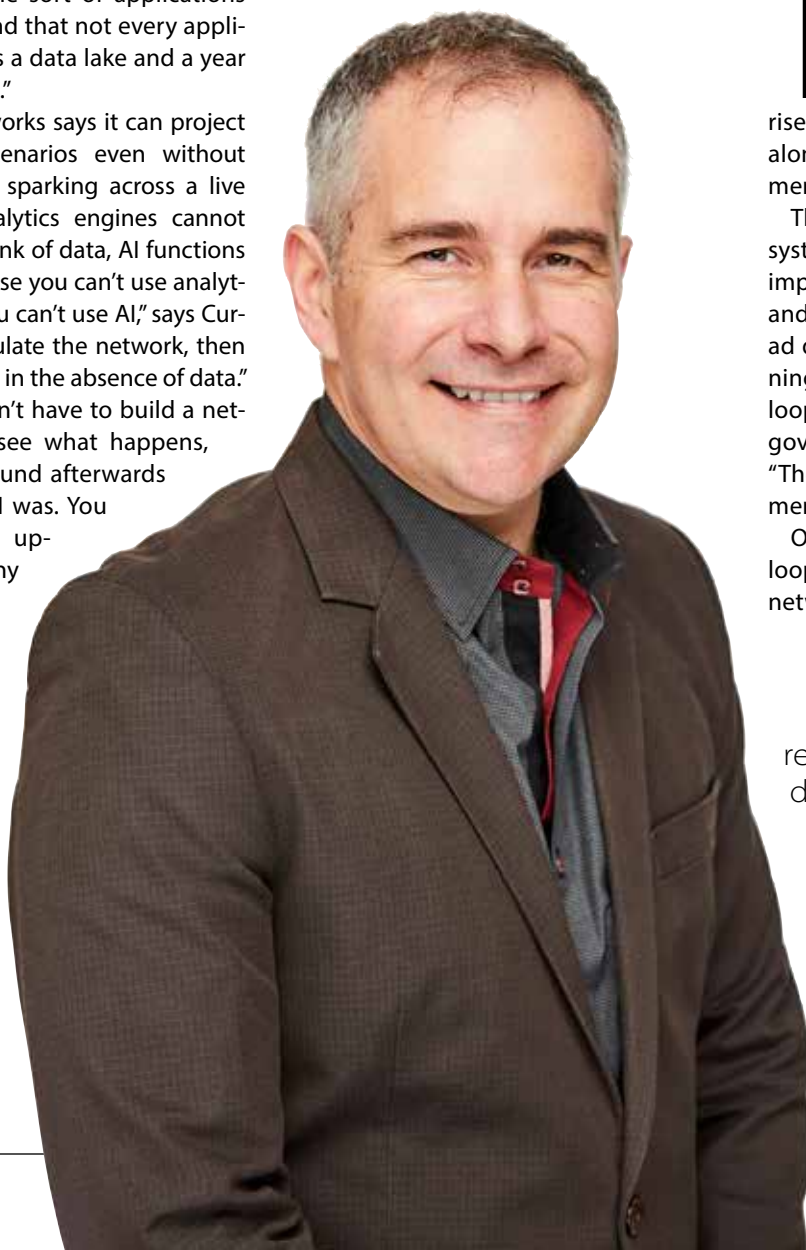
He adds: "That is the thing – every step of the way, from the network design through to the product life-cycle, there are decisions to be made, and 5G and IoT drastically reduce the time to make them. The only way we are going to make those quick decisions is with very clever people, and with AI."

Entrenched warfare | It's not the tech, it's the culture (*stupid!*)

The vision, of course, is telecoms goes from "man-based networks to self-driven autonomous networks", as Sihong at ZTE puts it, giving rise to self-healing and self-optimization, alongside intelligent, automated management and allocation of resources.

The application of AI in broad network systems is most essential if operators are to impose order on their data in the era of 5G and IoT communications. But these are salad days, still. The limited AI initiatives running in operators' networks remain open loop, notes Mavrakis. "For now, they are governed by manual processes," he says. "The point of all the discussions at the moment is to automate those."

Operators are not yet ready to close the loop, and let machines control parts of the network. "At the moment, these engines

"These engines do the analysis, and make the recommendation, but a human decides whether to implement the change or not. And it will be many years before this loop closes, at least for telecoms networks."

Dimitris Mavrakis, research director, ABI Research

Network – customer-facing applications retain AI at the network core; network-focused applications retain it at the edge.

do the analysis, and make the recommendation, but a human decides whether to implement the change or not. And it will be many years before this loop closes, at least for telecoms networks," he says.

But Ericsson says it is running closed-loop algorithms in the access network that process an array of data, including about the weather outside and alarms inside the network, to detect incoming issues and actuate fixes. "We have just started doing closed-loop parts, but they are on different levels. We haven't connected the loops in a good, orchestrated way yet," says Jägare.

Perrett at Aria Networks says the challenge is cultural, as much as it is technical. "At the moment, it's the engineers that are running the show. When it becomes more business focused, things will start to change quickly," he says. Even today, as the industry gallops ahead with virtualization, and starts to make such design flexibility innate, it is bridled by familiar constraints. As with its own digital transformation, its biggest enemy is often its own self.

AI and ML techniques in network design and optimization are mostly limited by

"At the moment, it is the engineers running the show - when it becomes more business-focused, things will start to change quickly."

Jay Perrett, chief technology officer, Aria Networks

their own author's appetite for disruption. "It's not that the problem is difficult, but that the root cause is not being addressed. There is a lot of focus on SDN and NFV, but it is all about the technology. It is a bottom-up approach," says Perrett.

Ericsson agrees. "No one comes to us to ask what the full ecosystem looks like, and how they should leverage AI as part of it. They are exploring one area at a time – they want to know about the edge computing, without considering the operational side, or *vice-versa*," says Jägare.

Her division is responding tactically. Its ML agent for NFV auto-tuning, discussed above, was developed with reinforcement learning by a small cross-functional team, she observes.

"When they were ready, they came to me and said, 'we've developed this optimization algorithm, and we think it can be deployed in any system or product'. The question was what to go for? For traditional OSS and BSS systems? And I said, 'no, let's do it somewhere else – because if we don't people will continue to think data analytics and machine intelligence is only a function of the network itself.'"

Fear is natural perhaps, but unhelpful when change is so urgent, says Montalvo at Telefónica.

"It may sound like a cliché but, as with other changes in our sector, implementing AI and ML is not just a question of technology, people, and skills. It starts with a cultural change at all levels of the organization – trusting that AI can be complicated to start with, and that managing the cultural change is essential to accelerate its adoption across a business."

He says operators must manage cultural change by education and training, as well as by re-writing underlying processes.

For Perrett, as well as the other commentators, the stakes are high, and getting higher. "In the context of 5G and IoT, AI is the part that's missing – SDN is great for programming, and NFV provides the functionality. But how do you put it together and make money? That's where AI comes in," he says. ((•))

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