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CASE STUDY

NOKIA'S "CONSCIOUS FACTORY" IN CHENNAI: A CASE STUDY IN DIGITAL TRANSFORMATION

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This case study highlights the impact of private networks in enabling Nokia's factory of the future vision and driving the digital transformation of the Chennai plant.

KEY TAKEAWAYS

- ***Nokia's Conscious Factory in Chennai, India is a representation of their vision of the Factory of the Future. It builds on the work done in Nokia's original Conscious Factory in Oulu, Finland, which has been recognized by the World Economic Forum in their Global Lighthouse Network.***
- ***The biggest driver for deploying a private wireless network at the Nokia Chennai plant was to achieve greater agility on the shop floor to accommodate the rising need for line configuration changes. Greater agility not only reduces costs incurred from "rewiring" but also boosts the productivity imperative.***
- ***One of the striking aspects of the Chennai plant has been the benefits realized by the creation of a digital twin on the back of connectivity of all major assets on the shop floor. This has enabled automation of the production flow and remote operation and maintenance, especially through the height of the pandemic-induced lockdown in India.***
- ***It is important to recognize that the long list of use cases that have transformed the Nokia Chennai plant have all been achieved on 4G LTE. Two small cells now cover the entire shop floor versus fifty-six legacy Wi-Fi access points. Once 5G becomes available in India, a host of new use cases can be rolled out.***

NOKIA'S CONSCIOUS FACTORY IN CHENNAI

Nokia's "Conscious Factory" is based in Oragadam on the outskirts of Chennai, India. The Chennai plant works closely with the parent factory in Oulu, Finland, which has been recognized by the World Economic Forum (WEF) as a 4th Industrial Revolution Lighthouse. While the Chennai plant was the first to deploy a private network, the two factories collaborate closely on Industry 4.0 initiatives and cross deployment of applications and use cases. The Chennai plant is built on 140,000 square meters and is adjacent to a Nokia "distribution Hub", which is used to ship products to over 100 countries around the world. The factory began in 2008 as a Nokia Siemens plant and over the years has produced a full range of equipment for 2G, 3G, 4G and now for 5G networks. Today, Nokia is increasingly producing 5G boards at this factory, including massive MIMO for base stations, as well as GPON equipment for fixed optical networks.

DEPLOYING A PRIVATE WIRELESS NETWORK

The Nokia Conscious Factory was originally wired with up to 120kms of Ethernet cable to connect production machines along with a legacy Wi-Fi network. In recent years, as the productivity imperative grew stronger, the existing connectivity network began to show its limitations.

- Nokia's business priorities have meant an increasing product mix shift towards 5G and GPON. The wired network, while boasting sufficient capacity and latency, had the problem that line configuration changes

Nokia has built a private wireless network based on 4G LTE using 2100 MHz spectrum from BSNL and Airtel. The entire shop floor has been covered with two small cells.

that arose due to changes in the product mix or new product transfers were difficult to execute. These line changes meant "re-wiring" the factory floor which was not only expensive but time consuming.

- For its part, the legacy Wi-Fi network was used primarily for employee communications but it was also used initially to connect the autonomous guided vehicles (AGVs) that were brought into the factory. However, once the decision was taken to move to an Industry 4.0 model, the coverage gaps and black spots inherent with a legacy Wi-Fi network were compounded by the lack of handover from one access point (AP) to another, limiting mobility for the AGVs.

As a result, a private wireless network (PWN) based on cellular technologies like 4G LTE was considered. However, India does not allow "enterprises" to directly own spectrum, and unlicensed is not an option except for Wi-Fi in the 5 GHz band which already had the limitations discussed previously. So, Nokia partnered with Communication Service Providers (CSPs) like BSNL (in 2018) and more recently, with Airtel, in 2020, to build a private wireless network using 4G LTE spectrum in the 2100 MHz band. The entire factory floor of 140,000 square meters is now covered with two small cells as compared to 56 legacy Wi-Fi APs. To be precise, Nokia has deployed four small cells, two from BSNL and two from Airtel, but two small cells are enough to cover the entire area. Nokia has deployed its proprietary universal IoT (UIoT) boxes to connect up machines on the shop floor while others are hooked up with LTE dongles.

Beyond connected endpoints, the private network has been rounded out by connection to a mobile core network that is hosted on-premises and the Nokia Digital Automation Cloud (NDAC), which includes edge compute and analytics as well as connectivity to cloud platforms like Microsoft Azure, where Nokia hosts its digital twin. The NDAC is hosted on-premise at the factory and is critical for the collection and analysis of all the telemetry and traffic data from the numerous sensors and connected endpoints on the shop floor. Nokia's factory digital twin is operational on the Microsoft Azure platform, providing access to Nokia employees from anywhere in the world. The creation of the digital twin took significant work to break down silos of data spread across machines and production processes. The entire set of SMT assemblies, inventory and warehouse, as well as testing areas have all been incorporated into a digital twin that is housed on the Microsoft Azure cloud, giving Nokia's factory operations team a full, real-time view of operations on the shop floor.

This case study highlights the wide ranging use cases deployed at the Conscious Factory in Chennai, ranging from access control to asset tracking and connected mobility.

USE CASES DEPLOYED AT THE CHENNAI CONSCIOUS FACTORY

Nokia has several major use cases that have been identified for the Chennai Conscious Factory and are now active. These use cases fall largely into 5 categories:

- Access Control
- Remote operations and Monitoring
- Connected Mobility
- Training and Skilling
- Asset tracking and inventory control

ACCESS CONTROL

Access control in the Nokia Chennai context refers to the ability to offer or restrict access to the shop floor and other designated areas. Two major use cases were identified and have been put into practice.

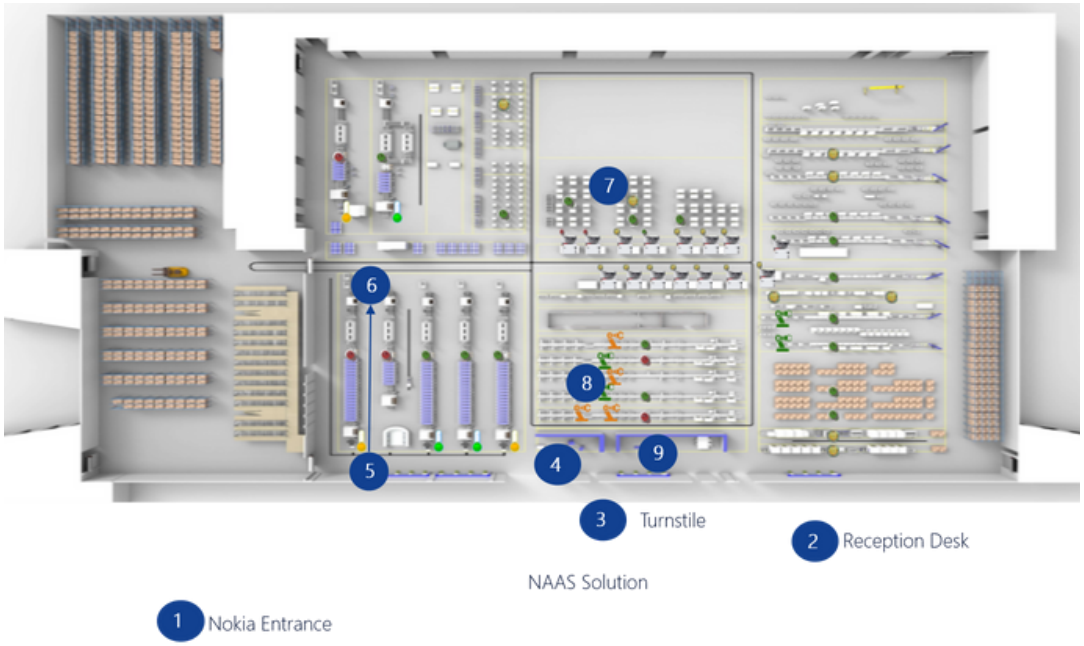
- **Reception Area** – is the very first area of access control at the factory. Here Nokia has deployed a solution called NAAS (Nokia Automated Analytic Solution for access control) that provides contactless temperature and PPE compliance of all employees & visitor checks and guides them for entry. Each employee passes through a designated area with prescribed social distancing around 6 feet away from the thermal imaging sensors. Temperature checks are done through the imaging sensors that record temperature and permit entry if within prescribed levels. With 3000 plus employees and contractors working at the Chennai plant in shifts, manual temperature checks and screening protocols mandated for pandemic prevention were cumulatively causing up to 3 hours in lost productivity time due to the delays for screening across three shifts. All data collected by the NAAS is processed locally on edge servers, with Nokia's SpaceTime analytics suite crunching the data to return real-time analysis and insights. None of this data is stored permanently or sent off site to the cloud for security and privacy considerations.
- **Restricted Zones** - are the second use case around access control in specific areas of the factory which are, for various reasons, restricted access zones. Usually, only designated employees who are trained and authorized to operate the equipment in those restricted zones can enter. Nokia has mounted fixed cameras to cover these zones with the video stream analysed to detect anomalies and intrusions. At this time, the system is only set up to detect intrusions, not to distinguish between authorized and non-authorized personnel. Emergency exits are also monitored to detect unauthorized ingress and egress into the factory areas. Here, beyond fixed cameras, sensors have also been installed to detect changes in the velocity of the air in these zones. In the event of unauthorized access, alerts are generated to notify the security control room who then respond to the breach.

Remote operations and monitoring are a crucial set of use cases enabled by the use of a private LTE network in conjunction with the digital twin platform hosted on Microsoft Azure.

REMOTE OPERATIONS AND MONITORING

Ultimately, Nokia's Chennai Conscious Factory is just that. A factory, with production targets that are crucial to the business. This factory has multiple surface-mount technology (SMT) production lines that generate boards for use in 4G and increasingly 5G radio products, as well as GPON products for fixed networks. The entire set of SMT assemblies, inventory and warehouse, as well as testing areas have all been incorporated into a digital twin that is housed on the Microsoft Azure cloud, giving Nokia's factory operations team a full, real-time view of operations on the shop floor. At the height of the pandemic and enforced lockdowns, Nokia was able to keep production lines running with limited staffing due to the enhanced automation of the lines.

FIGURE 1: DIGITAL TWIN OF NOKIA'S CONSCIOUS FACTORY IN CHENNAI



SOURCE: NOKIA

Two primary use cases were identified in this category:

- **Solder paste printing and inspection** – the soldering of components onto the SMT boards are done by human operators. However, even slight changes in the temperature and humidity surrounding the SMT lines can impact the soldering process and negatively impact the components' stability on the boards and thereby the performance. With the new 5G boards having a much higher component count, any "defects" in component soldering can cause quality issues and production delays. Sensors track and detect any changes in temperature and humidity and alert the operators so that they can identify the issue and fix the process. After soldering, all the boards are further inspected using an optical machine and then final checks are done with fully automated 3D inspection machine.

AGVs and AIVs are enabling a host of mobility use cases in the Chennai plant, all powered with a High Accuracy Indoor Positioning (HAIP) system.

- **Automated monitoring and production of massive MIMO boards** - where previously, the build of massive MIMO boards was done manually by human operators, Nokia has installed industrial robots that are now used for installation of the components. Not only do the industrial robots help Nokia's zero-touch, zero-defect approach but also reduces employee fatigue, which is a big plus. Beyond the automated production, Nokia can also remotely monitor the performance of the robots, which are connected through Nokia's UIoT boxes back to the NDAC. Remote monitoring not only helps Nokia plan for line configuration changes based on product mix changes but has also been a boon for employees who could not be on the shop floor due to lockdown-imposed restrictions.

CONNECTED MOBILITY

Nokia has introduced mobility use cases with autonomous guided vehicles on the shop floor. There are two primary use cases.

- **Autonomous Guided Vehicles (AGVs)** – these were introduced to help with the movement of heavy parts like aluminium castings. Previously, these parts would be moved manually by human operators using trolleys, racking up to 23 kilometres per day. Initially, the AGVs operated over the legacy Wi-Fi network but mobility was restricted to the small coverage areas of each Wi-Fi AP and handover was a problem. The LTE private network has expanded the coverage area but it is not sufficient. A further connectivity layer was added with tracks that incorporate RFID tags to act as station IDs. The AGVs are programmed to move only along these tracks and stop at the station IDs.

FIGURE 2: AUTONOMOUS INTELLIGENT VEHICLES (AIV)

SOURCE: NOKIA

Augmented reality use cases are also being deployed at the Chennai plant to help operators and technicians collect relevant information for performing tasks.

- **Autonomous Intelligent Vehicles (AIVs)** – Nokia has inducted a number of OMRON AIVs onto the shop floor. These AIVs are a step above the AGVs in that they need only be programmed once to be able to navigate around the entire shop floor. This helps their mobility beyond guided path tracks and open up more use cases.

To enable the seamless movement of the AGVs, AIVs and also to track the assets moving around the shop floor, Nokia has installed its High Accuracy Indoor Positioning (HAIP) system. The HAIP uses BLE readers that are placed around the shop floor to sync with BLE tags placed on all connected endpoints that are on the move. A good example of this is when a component on a board shows an error and needs to be routed to a tester. This could happen with the AIV, which syncs with the HAIP and can be tracked at all times as it works its way to its destination.

TRAINING AND SKILLING

Nokia has also invested in the training and skilling of their employees, in order to help them keep up with the frequent changes in the product mix that are seen at this plant but also to keep employees in line with the broader Industry 4.0 vision. There are two primary use cases.

- **Augmented Reality (AR)** – AR has been introduced at various locations through the shop floor. For example, all parts in the warehouse come in racks that can be “analysed” using the Nokia "Third Eye" software which will tell the technician or operator all they need to know. Every board has an identity with a barcode. When scanned, the operator can access historical data on the part that would show repair history, which is very useful in zeroing down to the defective part / location on the board, besides eliminating wasteful testing and double analysis. SMT board installers can also be guided through the numerous steps required with step-by-step instructions.

- **Virtual Reality (VR**) – the Chennai plant has a training centre setup on-premises for new and current employees. VR training modules have been developed in-house by Nokia and run the gamut of training for new employees on current product lines as well as for all employees on new products that emerge as a result of business decisions taken that impact the product mix. Another frequent scenario that requires training is when products are “transferred” from one factory in Nokia’s global chain to another.

With so many assets on the shop floor being connected to the private LTE network, Nokia is able to track all asset movement as well as manage inventory more seamlessly.

ASSET TRACKING AND INVENTORY CONTROL

One of the major sets of use cases at the Nokia Chennai plant relate to inventory and asset tracking as assets are moved around the shop floor from one process to another. To be clear, the first step was to connect all of the assets. These endpoints are connected through the UIoT boxes, LTE dongles and BLE tags, ranging across parts, machines and other assets.

- **Asset Tracking** – while the AGVs and AIVs are connected endpoints in their own right and need to be tracked as they navigate their way around the shop floor, Nokia has taken this concept further and placed BLE tags on all parts and assets that are potentially on the move. With a digital asset management system in place, the factory operations team will know the precise location of all assets, even if they have been misplaced or gone walkabout.

- **Inventory control** – Nokia has implemented a Warehouse "Pick to Light" system, where all parts are stored in racks across the store. If a part is required at one production station or testing area, an operator can enter the data into the asset management system and a light goes on at the specific rack in the warehouse to make it make it easy to locate the part in the specific storage rack, and further transport it to the required place on the shop floor. Less searching time means more productivity.

CONCLUSIONS AND FUTURE OUTLOOK

Nokia's Chennai Conscious Factory is fairly unique to India but also to emerging markets as a whole. Not only does it prove that Industry 4.0 can take root in markets like India but that these new technologies and use cases can move the needle on productivity and employee well being. Nokia is citing some impressive metrics, including 31% labour time reduction through robotic automation; 31,000 man hours saved through software robotic process automation (RPA); 16% OEE improvement since recent changes and others.

The journey has been far from easy with many challenges that needed to be overcome but the investments in a digital twin platform as well as building out the connectivity layer through a private LTE network have brought about a virtuous benefit cycle. The fact that all of the use cases described have all been enabled with 4G LTE holds some important lessons for keen observers. Several markets around the world are yet to rollout 5G commercially due to spectrum or business case challenges, while others have deployed but rollout has been slowed by the lack of chipset availability to support advanced features. Digital transformation of the manufacturing line, or any other vertical, can start today with 4G LTE, with the very real potential for significant performance upgrades once 5G is available as well as a host of new use cases.

ABOUT MANDALA INSIGHTS

Mandala Insights is an independent analyst firm that offers insights, opinions and research on the network technologies that will drive the next billion digital opportunities in Asia.

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