UNIT-V (CO5)

IoT Platforms, Arduino, Raspberry Pi Board, Other IoT Platforms; Data Analytics for IoT, Cloud for IoT, Cloud storage models & communication APIs, Attacks in IoT system, vulnerability analysis in IoT, IoT case studies: Smart Home, Smart framing etc.

IoT Platforms

An IoT platform is a multi-layer technology that enables straightforward provisioning, management, and automation of connected devices within the Internet of Things universe. It basically connects your hardware, however diverse, to the cloud by using flexible connectivity options, enterprise-grade security mechanisms, and broad data processing powers. For developers, an IoT platform provides a set of ready-to-use features that greatly speed up development of applications for connected devices as well as take care of scalability and cross-device compatibility.

Thus, an IoT platform can be wearing different hats depending on how you look at it. It is commonly referred to as middleware when we talk about how it connects remote devices to user applications (or other devices) and manages all the interactions between the hardware and the application layers. It is also known as a cloud enablement platform or IoT enablement platform to pinpoint its major business value that is empowering standard devices with cloud-based applications and services. Finally, under the name of the IoT application enablement platform, it shifts the focus to become key tool for IoT developers.

IoT Platform as the Middleware

IoT Platforms originated in the form of IoT middleware, which purpose was to function as a mediator between the hardware and application layers. Its primary tasks included data collection from the devices over different protocols and network topologies, remote device configuration and control, device management, and over-the-air firmware updates.

To be used in real-life heterogeneous IoT ecosystems, IoT middleware is expected to support integration with almost any connected device and blend in with third-party applications used by the device. This independence from underlying hardware and overhanging software allows a single IoT platform to manage any kind of connected device in the same straightforward way.

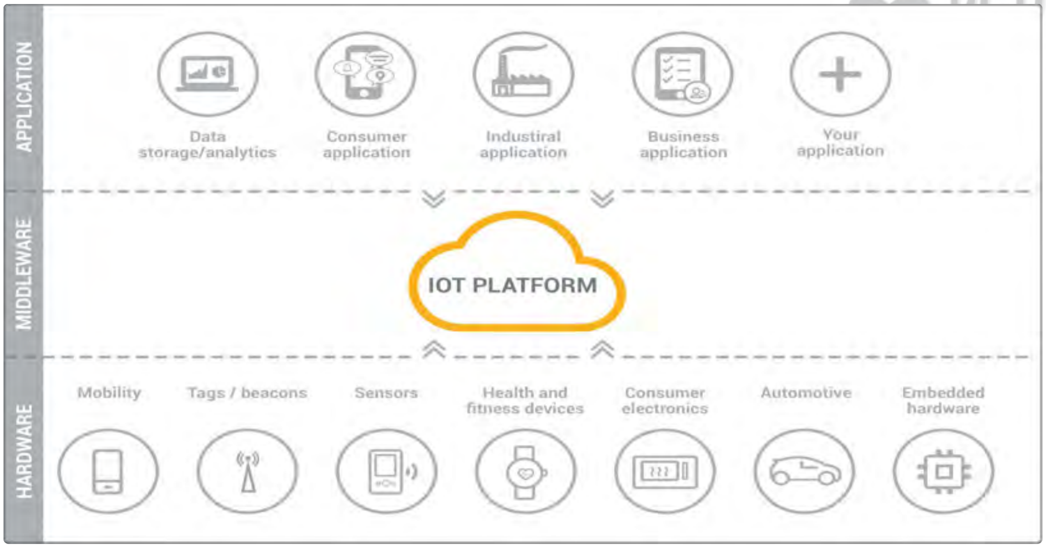

Figure 5.1: IoT Platform as the Middleware

Modern IoT platforms go further and introduce a variety of valuable features into the hardware and application layers as well. They provide components for frontend and analytics, on-device data processing, and cloud-based deployment. Some of them can handle end-to-end IoT solution implementation from the ground up.

IoT Platform Technology Stack

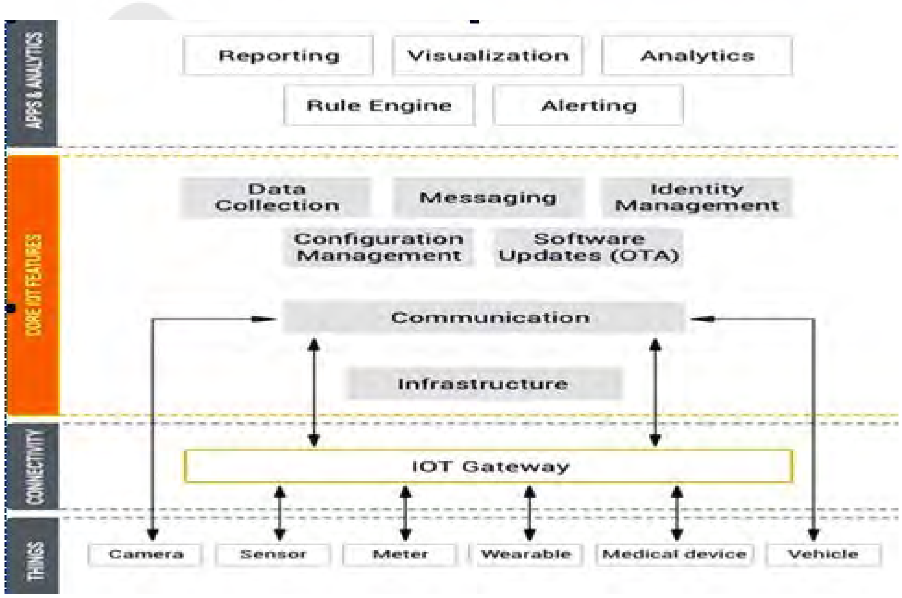

Figure 5.2 : IoT Platform Technology Stack

In the four typical layers of the IoT stack, which are things, connectivity, core IoT features, and applications & analytics, a top-of-the-range IoT platform should provide you with the majority of IoT functionality needed for developing your connected devices and smart things.

Your devices connect to the platform, which sits in the cloud or in your on-premises data center, either directly or by using an IoT gateway. A gateway comes useful whenever your endpoints aren't capable of direct cloud communication or, for example, you need some computing power on edge. You can also use an IoT gateway to convert protocols, for example, when your endpoints are in LoRaWan network, but you need them to communicate with the cloud over MQTT.

An IoT platform itself can be decomposed into several layers. At the bottom there is the infrastructure level, which is something that enables the functioning of the platform. You can find here components for container management, internal platform messaging, orchestration of IoT solution clusters, and others. The communication layer enables messaging for the devices; in other words, this is where devices connect to the cloud to perform different operations. The following layer represents core IoT features provided by the platform. Among the essential ones are data collection, device management, configuration management, messaging, and OTA software updates.

Importantly, the best IoT platforms allow you to add your own industry-specific components and third-party applications. Without such flexibility adapting an IoT platform for a particular business scenario could bear significant extra cost and delay the solution delivery indefinitely.

Arduino

Arduino acts as the brain of the system and processes the data from the sensor. Arduino is an open source hardware platform that is readily available for hobbyists & enthusiasts across the globe to build projects. It comes with an ATMEGA microcontroller that processes the data and facilitates the proper working of the IoT system. And the beauty is that the Arduino can be programmed 'n' number of times making it possible for you to build various types of IoT projects just by changing a simple code. You need to use C++ language for Arduino programming. Also, IDE software is needed for Arduino based IoT projects. And you need to use ESP-8266 WiFi module to establish the WiFi communication between the Arduino and cloud platform.

Arduino offer from simple 8-bit boards to products for IoT applications, wearable, 3D printing, and embedded environments. All Arduino boards are completely open-source, empowering users to build them independently and eventually adapt them to their particular needs. The software, too, is open-source, and it is growing through the contributions of users worldwide.

Advantage of Arduino

- **Inexpensive** - Arduino boards are relatively inexpensive compared to other microcontroller platforms. The least expensive version of the Arduino module can be assembled by hand, and even the pre-assembled Arduino modules cost is less.
- **Cross-platform** - The Arduino Software (IDE) runs on Windows, Macintosh OSX, and Linux operating systems. Most microcontroller systems are limited to Windows.
- **Simple, clear programming environment** - The Arduino Software (IDE) is easy-to-use for beginners, yet flexible enough for advanced users to take advantage of as well. It is conveniently based on the processing programming environment.
- **Open source and extensible software** - The Arduino software is published as open source tools, available for extension by experienced programmers. The language can be expanded through C++ libraries, and people wanting to understand the technical details can make the leap from Arduino to the AVR C programming language on which it is based.
- **Open source and extensible hardware** - The plans of the Arduino boards are published under a Creative Commons license, so experienced circuit designers can make their own version of the module, extending it and improving it. Even relatively inexperienced users can build the breadboard version of the module in order to understand how it works.

The Arduino UNO is the best board to get started with electronics and coding. If this is your first experience tinkering with the platform, the UNO is the most robust board you can start playing with. The UNO is the most used and documented board of the whole Arduino family.

Figure 5.3: Arduino Uno

Arduino Uno is a microcontroller board based on the ATmega328P. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz ceramic resonator (CSTCE16M0V53-R0), a USB connection, a power jack, an ICSP header and a reset button.

Raspberry Pi Board

The Raspberry pi is a single computer board with credit card size that can be used for many tasks that your computer does, like games, word processing, spreadsheets and to play HD video. It was established by the Raspberry pi foundation from the UK. It has been ready for public consumption since 2012 with the idea of making a low-cost educational microcomputer for students and children. The main purpose of designing the raspberry pi board is, to encourage learning, experimentation and innovation for school level students. The raspberry pi board is a portable and low cost. Maximum of the raspberry pi computers is used in mobile phones. In the 20th century, the growth of mobile computing technologies is very high, a huge segment of this being driven by the mobile industries. The 98% of the mobile phones were using ARM technology.

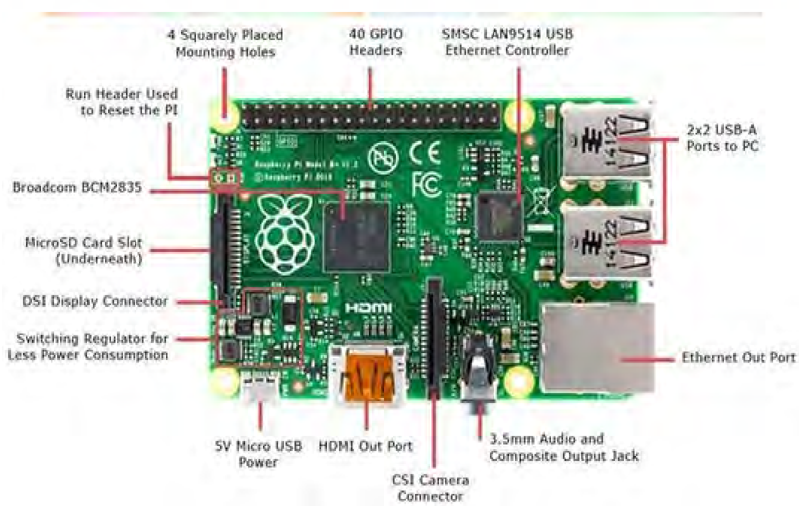

Figure 5.4: Raspberry Pi Board

Memory

The raspberry pi model aboard is designed with 256MB of SDRAM and model B is designed with 51MB.Raspberry pi is a small size PC compare with other PCs. The normal PCs RAM memory is available in gigabytes. But in raspberry pi board, the RAM memory is available more than 256MB or 512MB.

CPU (Central Processing Unit)

The Central processing unit is the brain of the raspberry pi board and that is responsible for carrying out the instructions of the computer through logical and mathematical operations. The raspberry pi uses ARM11 series processor, which has joined the ranks of the Samsung galaxy phone.

GPU (Graphics Processing Unit)

The GPU is a specialized chip in the raspberry pi board and that is designed to speed up the operation of image calculations. This board designed with a Broadcom video core IV and it supports OpenGL.

Ethernet Port

The Ethernet port of the raspberry pi is the main gateway for communicating with additional devices. The raspberry pi Ethernet port is used to plug your home router to access the internet.

Raspberry Pi Technology

The raspberry pi comes in two models, they are model A and model B. The main difference between model A and model B is USB port. Model aboard will consume less power and that does not include an Ethernet port. But the model B board includes an Ethernet port and designed in china. The raspberry pi comes with a set of open source technologies, i.e. communication and multimedia web technologies. In the year 2014, the foundation of the raspberry pi board launched the computer module that packages a model B raspberry pi board into module for use as a part of embedded systems, to encourage their use.

Other IoT platforms

An IoT platform serves as a mediator between the world of physical objects and the world of actionable insights. Combining numerous tools and functionalities, Internet of Things platforms enable you to build unique hardware and software products for collecting, storing, analyzing and managing the plethora of data generated by your connected devices and assets.

Google cloud IoT platform

Google launched its platform for Internet of Things development based on its end-to-end Google Cloud Platform. Currently, it's one of the world's top Internet of Things platforms. Google cloud IoT is the integration of various services that add value to connected solutions.

- Cloud IoT Core allows you to capture and handle device data. A device manager component is used to register devices with the service and monitor and configure them. MQTT and HTTP protocol bridges are used for device connection and communication with the Google cloud platform.
- Cloud pub/Sub performs data ingestion and message routing for further data processing.
- Google BigQuery enables secure real-time data analytics.
- AI platform applies machine learning features.
- Google data studio visualizes data by making reports and dashboards.
- Google maps platform helps visualize the location of connected assets.

The platform automatically integrates with internet of Things hardware producers such as Intel and microchip. It supports various operating systems, including debian Linux OS.

Core features of Google cloud IoT:

- AI and machine learning capabilities
- Real-time data analysis
- Strong data visualization
- Location tracking

List of the most popular Internet of Things platforms

- Google Cloud IoT
- Cisco IoT Cloud Connect
- Salesforce IoT Cloud
- IRI Voracity

- Particle
- IBM Watson IoT
- ThingWorx
- Amazon AWS IoT Core
- Microsoft Azure IoT Hub
- Oracle IoT

Data Analytics (DA) for IoT

The data generated from IoT devices turns out to be of value only if it gets subjected to analysis, which brings data analytics into the picture. Data Analytics (DA) is defined as a process, which is used to examine big and small data sets with varying data properties to extract meaningful conclusions and actionable insights. These conclusions are usually in the form of trends, patterns, and statistics that aid business organizations in proactively engaging with data to implement effective decision-making processes.

Data Analytics has a significant role to play in the growth and success of IoT applications and investments. Analytics tools will allow the business units to make effective use of their datasets as explained in the points listed below:

- Volume: There are huge clusters of data sets that IoT applications make use of. The business organizations need to manage these large volumes of data and need to analyze the same for extracting relevant patterns. These datasets along with real-time data can be analyzed easily and efficiently with data analytics software.
- Structure: IoT applications involve data sets that may have a varied structure as unstructured, semi-structured and structured data sets. There may also be a significant difference in the data formats and types. Data analytics will allow the business executive to analyze all of these varying sets of data using automated tools and software.
- Driving Revenue: The use of data analytics in IoT investments will allow the business units to gain an insight into customer preferences and choices. This would lead to the development of services and offers as per the customer demands and expectations. This, in turn, will improve the revenues and profits earned by the organizations.
- Competitive Edge: IoT is a buzzword in the current era of technology and there are numerous IoT application developers and providers present in the market. The use of data analytics in IoT investments will provide a business unit to offer better services and will, therefore, provide the ability to gain a competitive edge in the market.

Cloud for IoT

IoT cloud refers to any number of cloud services that power the IoT. These include the underlying infrastructure needed for processing and storing IoT data, whether in real time or not. IoT cloud also includes the services and standards necessary for connecting, managing, and securing different IoT devices and applications. As with other types of cloud services, such as software-as-a-service, organizations consume IoT cloud services as they need them, rather than building a datacenter or other on-premises infrastructure to deliver those services locally.

IoT cloud offers a more efficient, flexible, and scalable model for delivering the infrastructure and services needed to power IoT devices and applications. The IoT is virtually limitless in scale, unlike most organizations' resources. The cloud computing model effectively offers that kind of on-demand hyper scale, and it can do so in a cost-effective manner. IoT cloud enables organizations to leverage the significant potential of IoT without having to build the underlying infrastructure and services from scratch. IoT cloud also helps promote and ensure standardization in key areas, including how devices communicate with each other, device management, and security.

Cloud Storage Models for IoT

Cloud storage is in many ways a story of virtualization. Move to virtualization, where virtual and physical models begin to diverge, and finish with the cloud, where the physical is almost completely abstracted by virtual models. Who would have thought that storing bits could get so incredibly complicated? Storage has always contained a plethora of protocols, from Fiber Channel to iSCSI to SMB in all its variations, but the arrival of flash and the continual growth of virtualization have turned an already dense topic into a tangled jungle of acronyms, protocols, and abstractions. The virtualization of the data center has prompted a virtualization wave in storage as well, gradually pulling storage away from physical protocols and toward logical, abstracted storage models like instance storage and volume storage. By providing abstractions, the data center has steadily decoupled virtual machines from storage protocols.

The rise of cloud data centers has also spawned a new class of storage called object storage, which sacrifices the strong consistency of traditional storage protocols in order to provide single namespaces at a global scale.

At the root of all storage is some set of physical storage protocols, so I'll begin with a quick recap of physical storage. Three major classes of physical storage models are in use today: direct attached storage (DAS), the storage area network (SAN), and network attached storage (NAS).

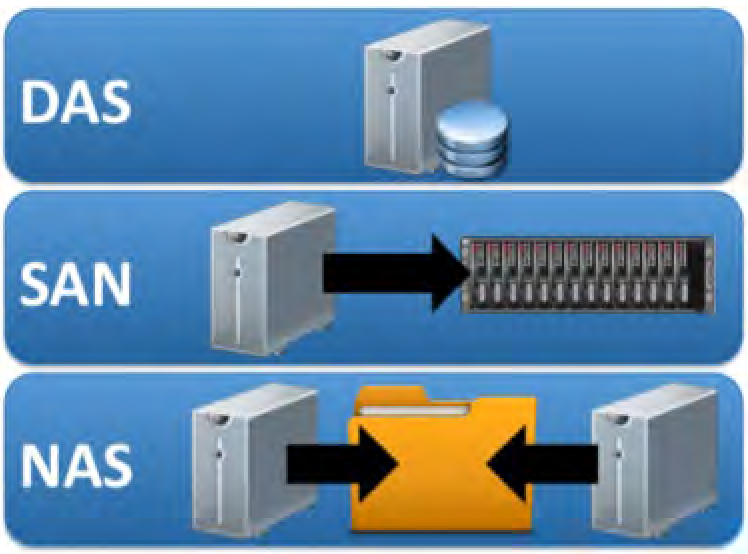

Figure 5.5: Cloud Storage Models for IoT

DAS (Direct attached storage). Direct attached storage is the simplest storage model. We are all familiar with DAS; this is the model used by most laptops, phones, and desktop computers. The fundamental unit in DAS is the computer itself; the storage for a server is not separable from the server itself. In the case of a phone it is physically impossible to remove the storage from the compute, but even in the case of servers, where it is theoretically possible to pull disk drives, once a drive is separated from the server, it is generally wiped before reuse. SCSI and SATA are examples of DAS protocols.

SAN (Storage Area Network). Eventually the storage industry recognized the utility of separating storage from the compute. Rather than attaching disks to each individual computer, we placed all the disks on a single cluster of servers and accessed the disk over the network. This simplifies storage management tasks such as backup and failure repair. This division of storage and compute is often called shared storage, since multiple computers will use a single pool of storage.

It was most straightforward to communicate between the client and server over the network using the same (or very similar) block protocols that were used to communicate with locally attached disk drives. Storage exposed this way is called a storage area network. Fibre Channel and iSCSI are examples of SAN protocols.

In a SAN an administrator will group a set of disks (or a portion of a set of disks) into a LUN (logical unit), which then behaves like a single disk drive to outside computers. The LUN is the fundamental unit used to manage SAN storage.

NAS (Network Attached Storage). While SANs allow us to move LUNs between one computer and another, the block protocols they use were not designed to concurrently share data in the same LUN between computers. To allow this kind of sharing we need a new kind of storage built for concurrent access. In this new kind of storage, we communicate with the storage using file system protocols, which closely resemble the file systems run on local computers. This kind of storage is known as network attached storage. NFS and SMB are examples of NAS protocols.

The file system abstraction allows multiple servers to access the same data at the same time. Multiple servers can read the same file at the same time, and multiple servers can place new files into the file system at the same time. Thus, NAS is a very convenient model for shared user or application data.

Popular Models for Cloud storage are:

1. Amazon Web Service (AWS)
2. XivelyCloud (PAAS)

Cloud Communication APIs

•Cloud Models are relied on Communication API. Communication API facilitates data transfer, control information transfer from application to cloud, one service to another. It also exists in the form of Communication Protocols. It supports RPC, PUBSUB and WAMP. E.g. Popular API is RESTful API (communication in cloud model). Django web framework is used to implement Communication API.

WAMP for IoT

•Web Application Messaging Protocol (WAMP) is a sub-protocol of Web Socket which provides publish–subscribe and remote procedure call (RPC) messaging patterns.

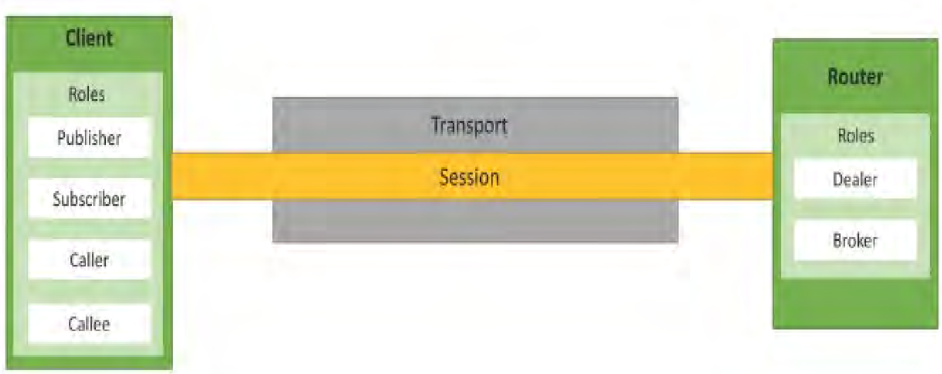

Figure 5.6: WAMP for IoT

WAMP –Concepts

•Transport: Transport is a channel that connects two peers.
•Session: Session is a conversation between two peers that runs over a transport.
•Client: Clients are peers that can have one or more roles.
•In the publish–subscribe model, the Client can have the following roles:–Publisher: Publisher publishes events (including payload) to the topic maintained by the Broker.–Subscriber: Subscriber subscribes to the topics and receives the events including the payload.

•In the RPC model, the Client can have the following roles: –Caller: Caller issues calls to the remote procedures along with call arguments. –Callee: Callee executes the procedures to which the calls are issued by the Caller and returns the results to the Caller.
•Router: Routers are peers that perform generic call and event routing.
•In the publish–subscribe model, the Router has the role of a Broker. It acts as a Router and routes messages published to a topic to all the subscribers subscribed to the topic.
•In the RPC model, the Router has the role of a Dealer. It acts a router and routes RPC calls from the Caller to the Callee and routes results from the Callee to the Caller.
•Application code: Application code runs on the Clients (Publisher, Subscriber, Callee or Caller).

Twilio communication API

- Twilio is a cloud communications API. This is sometimes referred to as communications platform as a service, or CPaaS. The term CPaaS emerged when companies like Twilio started offering application program interfaces (APIs)—a more developer-friendly and lower-cost option to integrate communications capabilities like voice, messaging, email, and video directly into software applications.

- Rather than building their own communications infrastructure from scratch, businesses that use cloud-based APIs from CPaaS vendors add real-time communications into their applications with a few lines of code. Unlike traditional communications infrastructure, communications built on a cloud communications platform are available without the burdens of capacity planning, carrier contracts, telecom hardware integration, and fragmented security.

- Cloud communications platforms like Twilio bring the world of communications to every web and mobile developer in the programming languages they already use. If a company is building a large, complex contact center, replacing a legacy corporate phone system, or building SMS notifications into a supply chain management app, the Twilio platform makes it simple. Without separate equipment, protocols, traditional infrastructure, telecom contracts, and software to deal with, the focus can be on building and iterating on the right solution for the task.

IoT Case Studies:

1. Case Study: IoT/Manufacturing of Cognizant

North American tools manufacturer implements Industry 4.0 technology to realize efficiencies and increase productivity in its global manufacturing operations. In industrial manufacturing, increasing productivity relative to fixed costs—plant, equipment, and personnel—boosts profitability. Today, opportunities to gain efficiencies are greater than ever, by integrating operational and digital technologies to create a unified view of intelligence that in turn boosts revenues.
Toolmaker remakes itself
Cognizant was selected by a leading global tool manufacturer to re-envision manufacturing operations by advancing their Industry 4.0 program. Our client has multiple lines of business and two fundamentally different types of facilities: 1. Assembly lines with few pieces of equipment but these are labor intensive. 2. Machining facilities with complex, asset-intensive production lines. The company has more than 100 factories worldwide, with machines varying in age and complexity. It faced limitations on communicating and coordinating between 1facilities. Our client knew it had a "Greenfield" opportunity to transition cleanly to digital. Its objective was to create significant value in the next five years as it moves from a focus on efficiency improvements to an Industry 4.0 platform that promotes connectivity and digital visualization to create value. Targeted outcomes include improved accuracy in order fulfillment, lower production error rates, lower energy costs, and improved safety and compliance.

Success by design

Blueprint for Industry 4.0 implementation was an integrated, cloud-based platform for gathering, analyzing and sharing information from disparate factories, increasing visibility and making resource allocation more efficient. Our client had various data-gathering protocols across its global footprint of facilities, including manual protocols. Management knew that by streamlining and consolidating data capture from production equipment and assembly lines, it could gain insight into its manufacturing processes and optimize them. We inventoried equipment and production machinery worldwide, gauged readiness for incrementing equipment and production lines with sensors and gathered meaningful information centrally. We created and retrofitted equipment with state-of-the-art wireless IoT sensors to allow for monitoring efficiency and up time, yield, and productivity measures for workers, assets and entire facilities, to understand how assets performed to ensure quality.

We then designed and deployed an IoT platform an “operational nerve center” to demonstrate the forecasted benefit of Industry 4.0 to management and manufacturing personnel and implemented the platform at four plants in less than twelve weeks. This showed how cloud-connected and sensor-instrumented production devices would allow monitoring and flexible decision-making through analytics. We then rolled out the solutions globally, establishing secure enterprise-wide connectivity without disrupting the business, creating a network of plants that respond quickly to changing needs using digital twins. Measures for OEE are now embedded in manufacturing processes, providing managers detail on asset availability and run-time, configuration and customization, scheduling, through-put and quality output, even down-time or maintenance needs. Real-time notifications and web-based user interfaces enable remote experts to collaborate with shop-floor personnel, empowering the company’s next generation of smart workers. Better asset use promotes efficiency and lowers energy use.

Right tools, right choice Cognizant was selected to help our client implement their vision to develop a comprehensive solution to scale beyond the pilot and create business value. Our combined, deep capabilities in manufacturing operations and industrial automation, and our proven experience in large-scale technology implementations, were critical to our client’s success.

Expertise in agile development allowed us to partner with our client’s development teams to implement state-of-the-art web-based user interfaces and collaboration tools. Teams across the globe are rapidly enhancing functionality using the Industry 4.0 reference architecture, a suite of software tools, prescriptive, reusable templates and protocols for realizing OEE. They are using robust, extensible information model to enable app development, analytics and reporting. A set of best practices are guiding more than 100 facilities across the company’s global network toward its new future.

2. The Veolia Vision Air customer portal: an industrial IoT case study

Tribal Systems was asked to create the Vision Air portal for Veolia Water Technologies.

Veolia's requirement

Veolia wanted to use the latest technology that the internet makes possible to create a better experience for its customers in the countries across Europe. It wanted to give it customers instant access to their service scheduled, service reports, documentation, orders, contract coverage, and live feeds of data from their Veolia equipment, all while putting Veolia's support team just a click away.

Solution summary

Experienced in industrial IoT solutions, Tribal's consultancy team devised together a solution which included the development of an online customer portal, integration with Veolia's ERP systems, and 24/7 connected water treatment systems through Sierra Wireless Air Vantage IoT infrastructure.

The Challenge

Veolia supply water treatment equipment and services to a range of industries. It serves customers in the pharmaceutical industry, food and beverage, chemical processing, power, research and healthcare. Customers in these industries rely on water treatment to keep their businesses operating efficiently, as any decline in the quality of water in those processes means increased cost.

The solution to this challenge needed to encompass giving customers a clear view of upcoming service visits on their equipment and up to the minute data on the performance of equipment so that interventions could be planned, and problems dealt with quickly.

The Tribal Systems solution

For our consulting team there were some key components that needed to be brought together.

User-friendly interface

For the human interface of the portal, we deployed our IoT customer portal platform based on Asset wolf. This allowed us to create a user-friendly portal design in the Veolia brand.

