IoT & Cognitive Computing Approach to Managing Equipment

Connect ⟶ Predict ⟶ Repair ⟶ Optimize

A Technical Paper prepared for SCTE•ISBE by

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1. Introduction – Connected Devices

The Internet of Things (IoT) is radically changing the way businesses operate and people interact. Billions of devices, sensors, and chips—many of them simple, everyday objects—can communicate with us and each other. Hospitals can monitor and regulate pacemakers at long distance, factories can automatically address production line issues, and hotels can adjust temperature and lighting based on a guest's preferences.

The IoT is changing the nature of products and equipment, as well as customers' expectations of their partners and suppliers. Consumers are pressing for greater accountability and better outcomes from manufacturers for the products and services they provide. As more devices connect the user experience directly back to the manufacturer, it creates expectations that the manufacturer is aware a problem is occurring, and potentially even before it occurs. Organizations like John Deere used to "simply" provide equipment to farmers, yet these farmers are now expecting John Deere to help them use the equipment more effectively. These rapidly changing expectations create both opportunities and challenges. Michael Porter and James Heppelmann summarized it well in The Harvard Business Review:

> *Once composed solely of mechanical and electrical parts, products have become complex systems that combine hardware, sensors, data storage, microprocessors, software, and connectivity in myriad ways. These "smart, connected products"—made possible by vast improvements in processing power and device miniaturization and by the network benefits of ubiquitous wireless connectivity—have unleashed a new era of competition. (How Smart, Connected Products are Transforming Competition, 2014)*

1.1. Connected Devices, Analytics, and Cognitive Computing

IoT is not just about connecting devices. It is a critical first step, but ultimately an enabling one for what follows. An IoT of billions of devices and sensors is pointless unless it effectively utilizes the flow of information. Most of the data generated from these devices will never be used as it simply cannot be understood in time to act. As described in a recent McKinsey Global Institute report:

> *Currently, most IoT data are not used. For example, on an oil rig that has 30,000 sensors, only 1 percent of the data are examined. That's because this information is used mostly to detect and control anomalies—not for optimization and prediction, which provide the greatest value. (The Value of Digitizing the Physical World, 2015)*

IoT is about the creation of new insights by analyzing the data that the connected devices generate. First movers are already shifting focus to make sense of the data as it is generated and leverage it for higher value functions. Companies are adopting analytics solutions to process the data for diagnosing problems, predicting outages before they occur, and prescribing solutions.

This use of analytics is also having an impact on existing sensor placements as well their modus operandi – including new sensors or relocating sensors for the purpose of predictive analytics. Classic use of sensors have been to ensure proper operation and quality control. Connected device capabilities now include lifecycle reliability characteristics monitoring – prevent catastrophic failures and extend the useful life thus reducing total cost of operations (TCO).

However, traditional analytics have limitations when it comes to identifying relationships among unstructured data, such as equipment manuals, work orders, and service history. This is where cognitive computing comes into play.

Cognitive augmented intelligence infuses thinking into objects, systems, and process. It provides new opportunities to ingest and analyze data, including unstructured data. Through cognitive capabilities, systems can continuously learn, interpret, and respond. Advanced cognitive systems can communicate via natural language… see, listen and learn.

Cognitive computing and traditional analytics are two sides of the same coin and both are required to achieve business results:

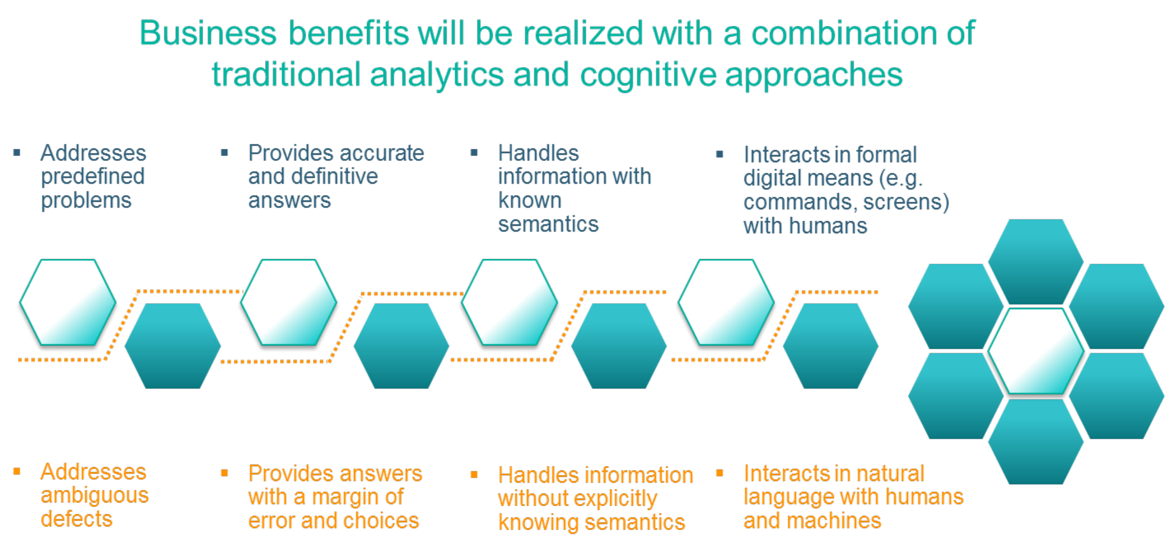

Figure 1 – Business Benefits will be realized with a combination of traditional analytics and cognitive approaches

The combination of IoT with cognitive capabilities opens new avenues for clients to boost operational performance, enhance customer experience, and lead industry transformation:

- Work smarter by providing employees cognitive insights from a company’s collective knowledge of information
- Give equipment and devices the power to reason and learn, and the ability to interact naturally with people
- Facilitate expedient repair of broken or faulty equipment via a cognitive assistant

1.2. Connected Devices and People

Capitalizing on the IoT will further accelerate the shift to what we call Digital Operations. Digital Operations can be defined as a deliberate strategy of transforming businesses through analytics-led, Internet of Things enabled, business and operating models focused on predictive decision making and optimized efficiency.

Few organizations, however, believe they are ready for that scale of change. IBM's Institute for Business Value (IBV) has documented C-level concerns that the pace and breadth of change are beyond their current people's ability to address them. Capitalizing on the IoT will require organizations to rethink how their process engineering integrates IoT services into manufacturing and delivery. Additional data science and quantitative analysis skills, which are already in short supply, will be required to make smart use of the pending flood of IoT generated information streams. Further, IBV research determined that organizations are not sufficiently building the people resources required to address changes resulting from IoT.

Any IoT solution must consider the implications on the organization's people or it will ultimately be limiting and ineffective. Both data and people are essential linchpins in a holistic IoT solution because of the requirement for the right information, processed the right way, driving the right actions by machines and humans. Simply put – the best data in the world will not help unless people can put it to effective use. Since cost and talent issues prevent "throwing people at it", the effectiveness of the employee needs to be raised to collectively become a smarter organization. We are not implying the replacement of humans by machines, but cognitive systems communicating insights that expand the boundaries of what can be known and acted on. IoT will continue to change the nature of how machines and humans work together.

By its very nature, the IoT is a connected web of interdependencies. An effective IoT strategy requires addressing both data and human challenges to succeed. Aggregating these elements brings true business value.

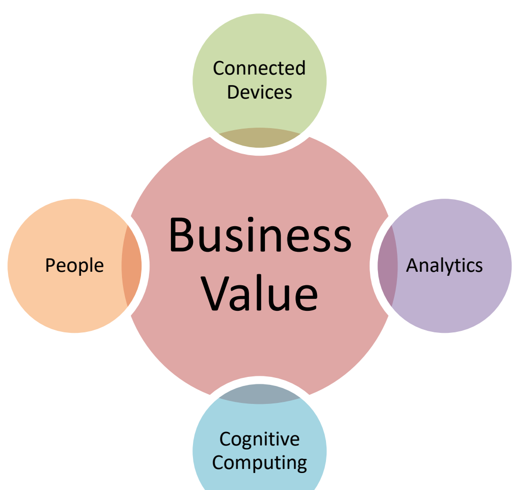

Figure 2 – Connected Devices + Analytics + Cognitive Computing + People brings Business Value

2. Maintaining Equipment

By nature, the equipment management ecosystem has had its own current set of challenges before the IoT. As the interdependencies and complexity of operations has increased (whether in an Industrial, Commercial, Mobile, or Consumer-based setting) over the last 2+ decades with advancing control technologies, it has created a new set of challenges:

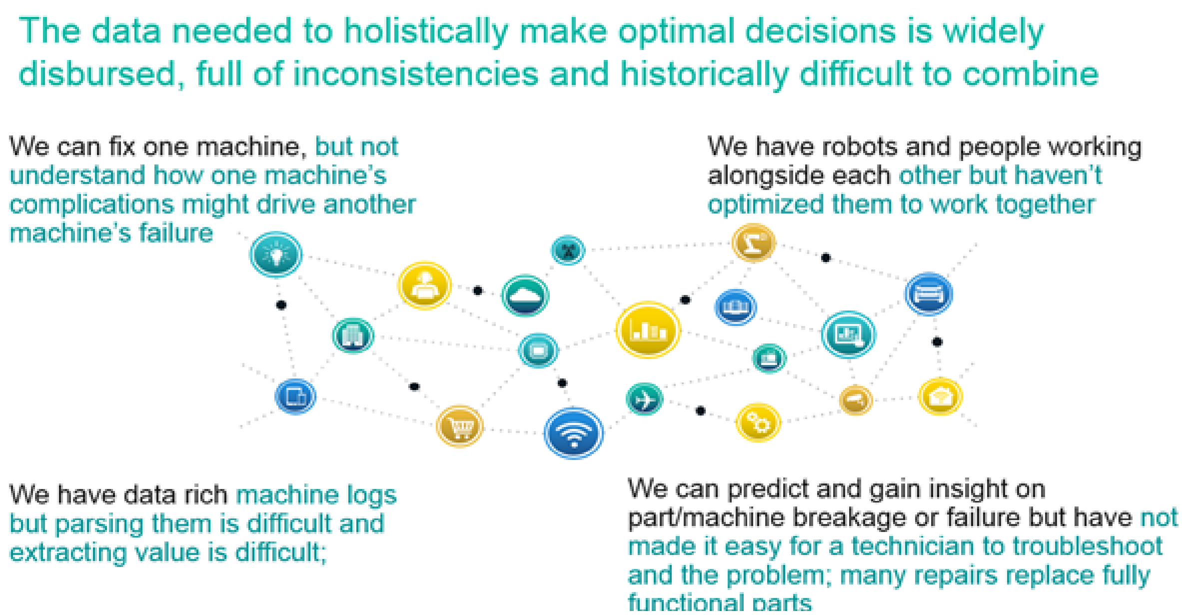

Figure 3 – The data needed to holistically make optimal decisions is widely disbursed, full of inconsistencies and historically difficult to combine

connect to equipment, **predict** equipment or system failures before they occur, facilitate **repair**, and **optimize** their operations.

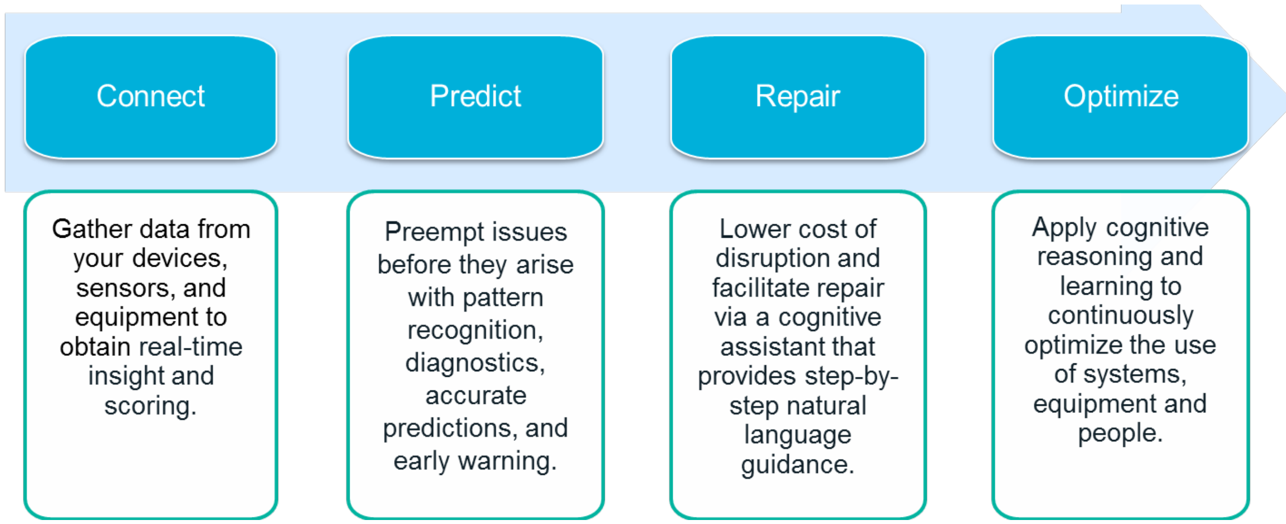

Figure 4 – Connect → Predict → Repair → Optimize

2.1. Connect

For multiple decades, electronic sensors have been a staple in the manufacturing industry, in transportation, in consumer products, in utilities and across all other industries. Availability and accessibility to that data has been done in the form of many disparate systems, databases and solutions. The IoT platform enables quick connection of devices, sensors and data and infuses intelligence into applications and services. The Predict and Optimize pillars are big consumers of both realtime and historic data, and the intravenous access provided by the IoT platform is transforming equipment management.

The IoT platform leverages AI to enable real-time insights, natural language processing, machine learning, and video/image/audio analytics. The AI takes the data inputs from connected devices and other sources to uncover patterns and insights previously unattainable. It recommends and implements actions such as safety controls, energy management, and quality assurance.

Key elements include communications with multiple protocols, analytics tools, device data storage, application development environment, data protection, and integration with third party devices and platforms. This approach utilizes the data received from connected devices to feed real-time data into the Predict pillar.

2.2. Predict

Suggesting the obvious, identifying and solving problems before they occur is less expensive and prevents operational disruption.

Work with multiple data sources to generate models targeted at predicting asset failure or quality issues so your organization can avoid costly downtime and reduce maintenance costs. Predictive analytics can detect even minor anomalies and failure patterns to determine the assets and operational processes that are at the greatest risk of problems or failure. This early identification of potential concerns helps you deploy limited resources more cost effectively, maximize equipment uptime and enhance quality and supply chain processes, ultimately improving customer satisfaction.

This approach utilizes analytics to:

- Provide predictive indicators of pending asset failures
- Quickly identify primary variables as part of root cause analysis
- Minimize product quality and reliability issues via early warning indicators
- Optimize spare-parts inventory and help to normalize an unpredictable supply chain
- Provide advance indicators of warranty claims to increase customer satisfaction
- Enhance sales and operations planning to reduce operations costs

It is the output generated from predictive analytics that becomes the input to the Repair pillar to initiate human action as needed.

2.3. Repair

As the IoT transforms customer expectations and competitive pressures, demands on the people working within those industries also increases. This further stresses the human side of product and service delivery and creates problems moving to a digital operations model.

At a field engagement level, the flood of data creates additional challenges for effective service delivery. Field Technicians are often overwhelmed with information from a variety of internal and external data sources.

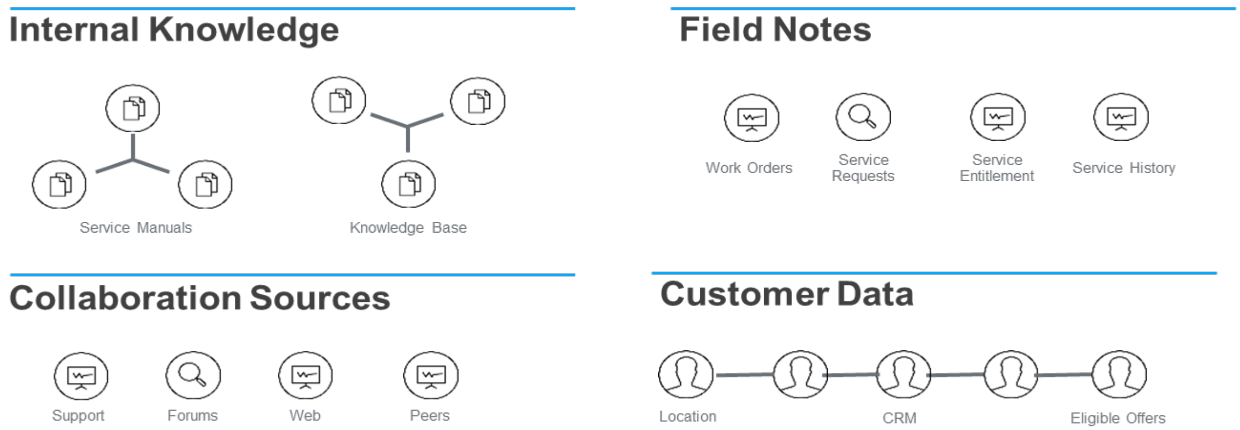

Figure 5 – Organization of knowledge sources

As machinery and equipment evolves in the IoT era and becomes more complex, the requisite skills and knowledge to repair the systems also increases. Often, there is a lack of effective methods to diagnose and resolve issues quickly out in the field. This impacts company operations and customer satisfaction and potentially drives poor use of parts and resources.

To solve these challenges, companies are leveraging AI as a cognitive advisor for field service technicians. AI ingests various forms of information related to the equipment and repair of it; service manuals, knowledge base, service history, support information, forums, client information, etc. AI learns from this information to develop the best of course of action for repairing the equipment. When an outage or breakage occurs, the technicians can engage AI directly over a simple interface including diagnosis and chat, connecting to current internal systems for specific data. The technician can communicate with AI in natural language to obtain help in diagnosing the problem and step-by-step repair instructions. AI can continue to support the field technician if there are questions or additional information needed as they work on the repair. Field technicians can interact with AI conventionally via a keyboard, or as useful, verbally via Speech-to-Text. AI understands the context that the field technician is asking and can down-select the likely materials and interactions from the Connect and Predict parts of the process that initiated the Repair cycle.

Based on the flexible nature of an IoT Platform building blocks, the solution can be adapted to meet specific business needs. For example, AI could use visual recognition to help identify the type of equipment and the nature of the problem to further expedite repair.

This approach utilizes AI to:

- Ensure problems are fixed correctly the first time – First time to fix metric
- Decrease repair costs by lowering time spent on repair – Mean time to repair (MTTR)

- Optimize training by providing a cognitive tool for teaching – helping to address the aging workforce challenge faced by many industries
- Drive incremental revenue by creating new services opportunities
- Improve customer satisfaction

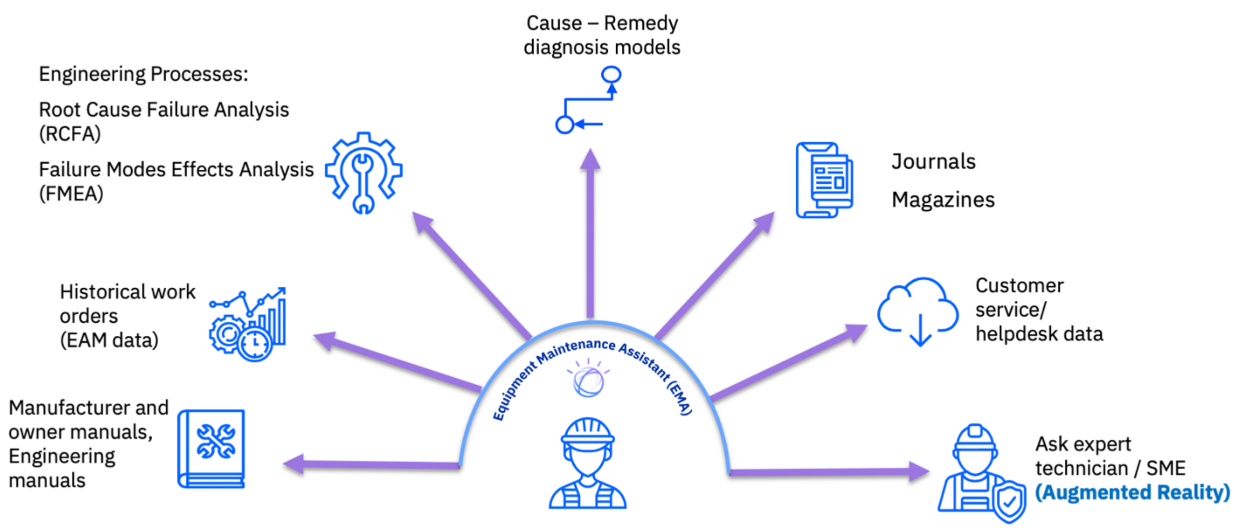

Figure 6 – Operationalization of AI technology through natural language queries (NLQ), troubleshooting diagnosis and augmented reality (AR)

2.4. Optimize

This is defined as the Optimize step as an approach that systematically improves outcomes through continual closed-loop learning. Closed-loop learning means that the recommendations are compared to actual outcomes after the actions have been performed. Learning from predictions, while not as widespread as it should be, is not in itself new but this approach addresses a key gap in the process. While this approach learns consistently with machine learning approaches, it also actively learns from the human activity side of the IoT. More specifically, this approach learns from how humans interact with the predictive analytics predictions and how the work was successfully accomplished to both improve the statistical modeling to predict the future and how subsequent engagements provide better context to the people actually doing the work.

Optimize applies cognitive computing and analytics to provide closed-loop learning based on outcomes to constantly improve the usage of systems, equipment, and people. It requires a consultative approach to determine specific areas in the process that could be optimized. There is no "one-size-fits-all" approach and the technology is based on the use case and desired outcome.

Following are some of the areas that we are currently working with clients to optimize their use of machinery and equipment:

- Identify correlations in separate defects among interdependent clusters of systems to improve repair efficiency
- Enhance first-time-fix effectiveness by predicting other components that may fail due to the repair
- Improve cognitive learning based on the outcomes of previous repair jobs for a selected asset or similar repair jobs on like assets
- Leverage machine learning and AI's visual recognition to evaluate manufacturing performance and make recommendations to alter parameters to improve the process

3. High level Architecture

As described above, this approach consists of four pillars; Connect, Predict, Repair, Optimize. The modular approach provides opportunity for a phased approach. However, the value from the aggregation and integration of the parts exceeds the sum of the individual components. Following is a sample architecture connecting these four areas into one solution.

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3.1. Technical Architecture

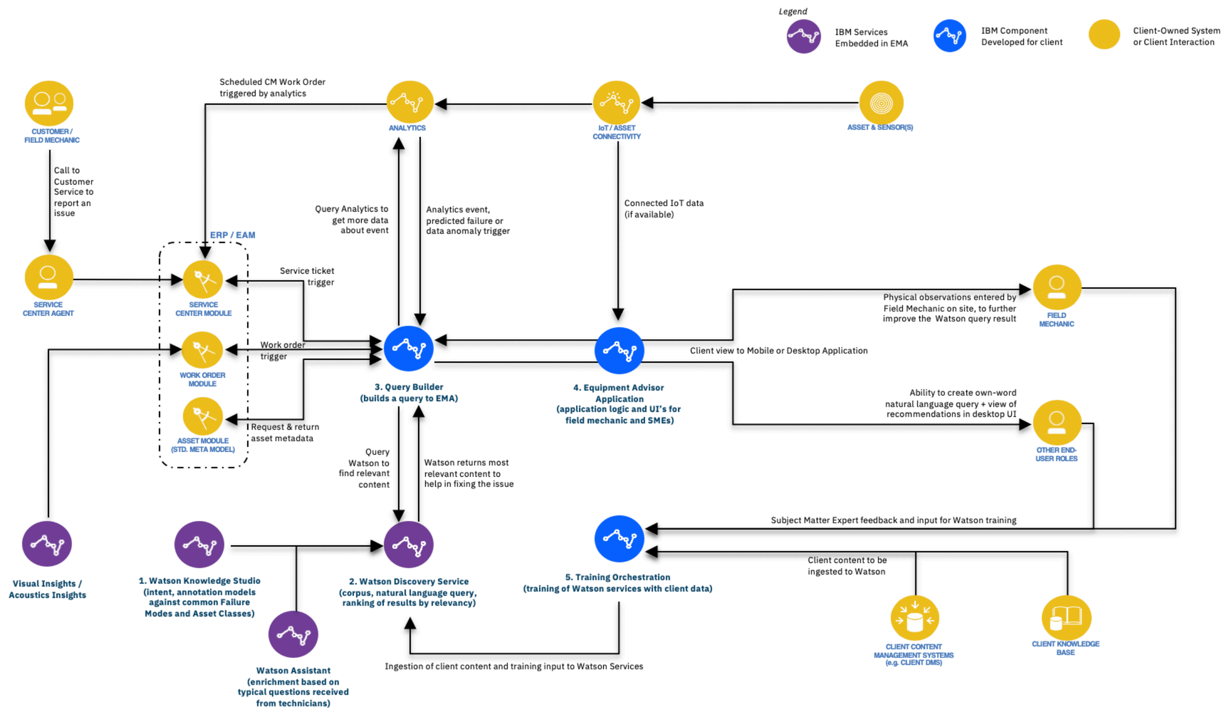

Figure 7 – High-level architecture

In this example, sensors connected to the equipment provide real-time updates to monitor the activity. Predictive analytics are used to evaluate the operational health of the equipment and provide early warnings of trouble. Machine learning continuously sweeps for non-obvious patterns. AI can ingest information from structured and unstructured sources to more quickly identify the issue. Visual cues are provided to display early warnings and if necessary, a repair request is initiated. The field technician leverages AI to obtain step-by-step instructions on the repair using natural language processing and conversation. AI continues to learn and develop a corpus of information through the process which provides continuous improvement.

Abbreviations

AI	Augmented Intelligence
IoT	Internet of Things
MTTR	Mean Time to Repair
FTTF	First Time to Fix
TCO	Total Cost of Operations
NLQ	Natural Language Query
AR	Augmented Reality
SCTE	Society of Cable Telecommunications Engineers