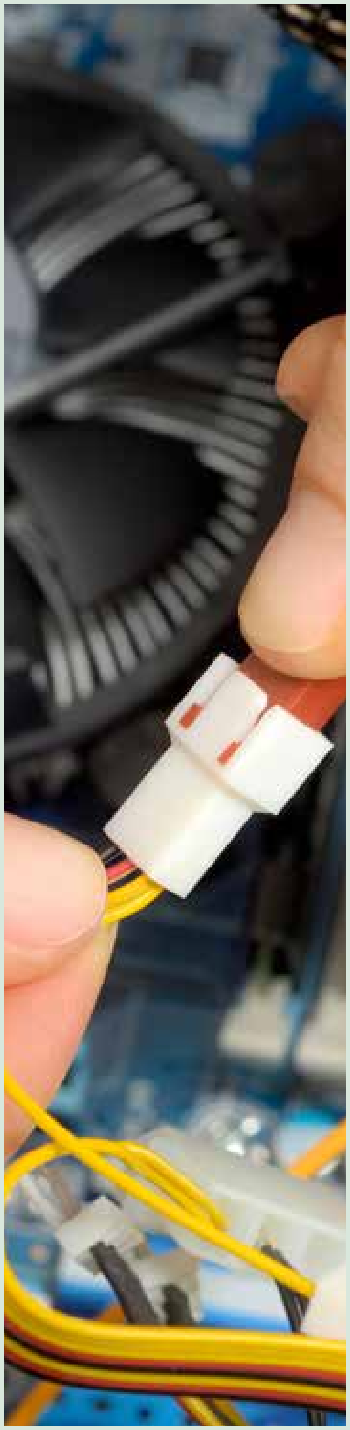
WHITE PAPER



THE FUTURE OF MAINTENANCE

Abstract

Today, a significant amount of the world's global GDP is being spent on maintenance activities, especially for addressing equipment breakdown or failure. Operational efficiency, equipment ROI and safety considerations give rise to an industry need to ensure that the equipment is functional and utilized to its potential. The maintenance function is evolving from being after-the-fact, to planned, to predictive to finally self-fixing. Emerging domains like M2M communication, developments in operational sensor technologies, combined with advances in information technologies including cloud-based platforms, big data and analytics are helping unlock the unused potential of consumer equipment by providing real-time data on performance levels. Based on these inputs, a maintenance schedule can be outlined which will help maintain the right parts with the right means without losing equipment efficiency. This will mitigate unnecessary spends and repeated failures.

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A data-based approach is taking maintenance to the next level and 'Maintenance-as-a-Service' will soon become the order of the day. This approach will allow equipment to be monitored and fixed remotely with a potential functionality to even heal itself. New business models will emerge wherein a product will be sold not at a fixed price, but rather on the basis of the throughput it can deliver in a given time. The manufacturers will take responsibility for the equipment and ensure that you get the most out of it while they receive an annuity and additional business based on product and service quality. Total cost of ownership will soon take center stage as the key measure of success.

In this paper we discuss the technologies to consider, their integration and the key considerations of such an initiative.

Introduction

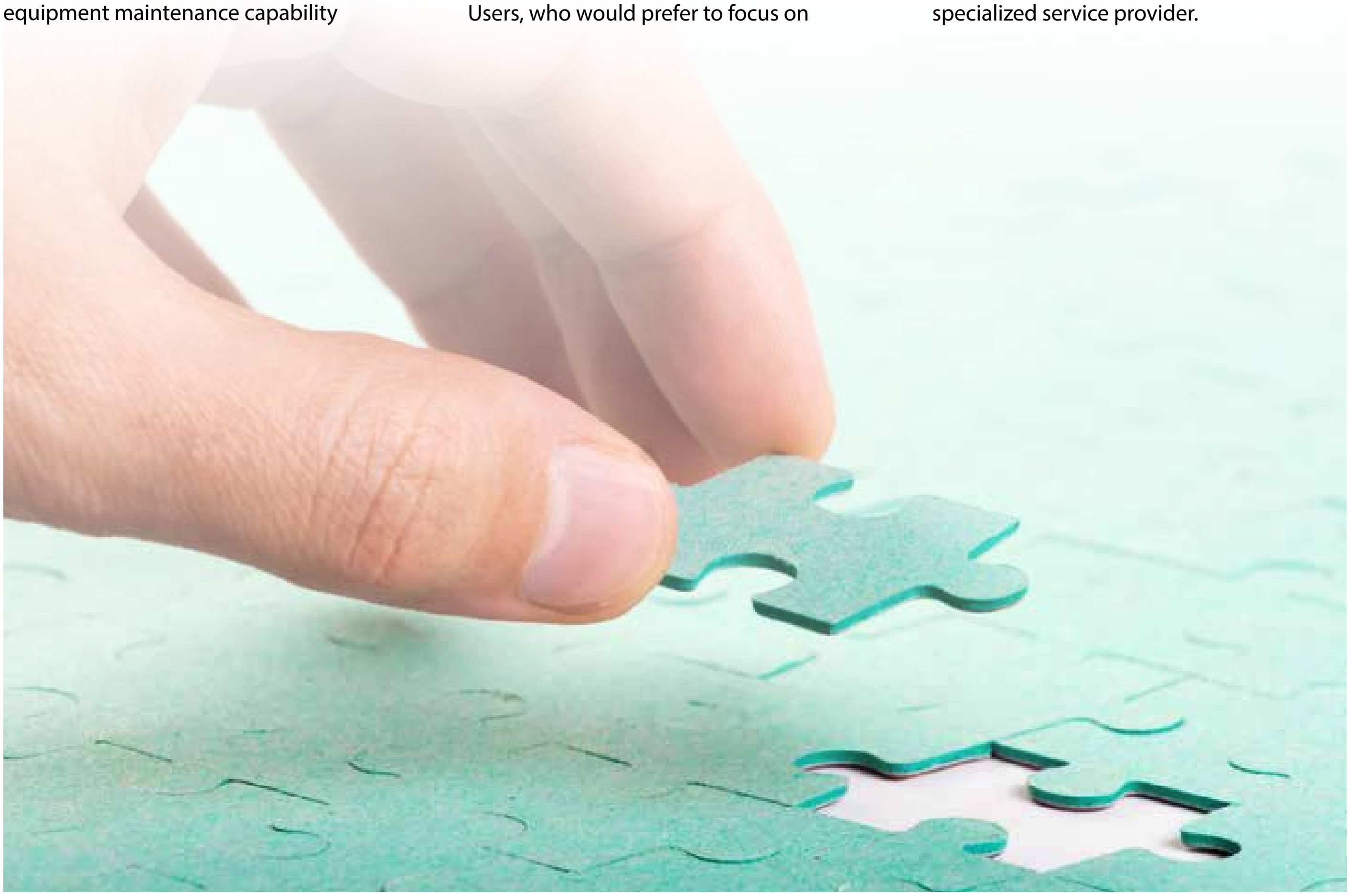
Loyal customers are the most sought after assets that give your business a competitive edge. Winning customer loyalty for your product is exceptionally important in today's competitive business environment and forms the core of most business strategies. Producing classy and efficient products is not enough; they should be clubbed with performance-based services that bind customers into a sustained relationship. These services must be tightly integrated with the product along with a robust support ecosystem to create a success story. Services will include technical support on product usage, supply of consumables and maintenance services which form the most significant portion among the services provided.

Maintenance services are critical as they directly impact operational efficiency and equipment uptime. Organizations have evolved their maintenance strategies from fixing broken equipment to planned maintenance to following the product vendor's recommendations to ensure maximum uptime and efficient asset operations.

Following an approach, based on heuristics or standard guidelines, leaves behind un-used potential of parts that still have an amount of useful life remaining and repeated maintenance service costs that could be avoided. While this is known to the industry, the absence of a reliable and affordable mechanism to predict the condition of the equipment has prevented them from adopting condition-based or predictive maintenance to realize maximum value.

New products are complex and need specialized skills to maintain them

Today, equipment design leverages the latest advances in technology to meet the tight quality and efficiency standards of an ever-demanding operating environment. This challenges ordinary users to acquire multidimensional equipment maintenance capability comprising skills, tools, system knowledge and the desire to get into maintenance details. The maintenance of these assets at optimal operational efficiency levels is an important requisite for business success and continues to be a challenge. Users, who would prefer to focus on solving core business problems, rather than on complex maintenance activities, would find value in a maintenance-as-a-service offering. Newer technologies enable exactly such services, which may be managed via a product vendor or specialized service provider.



Emerging technologies have a lot to offer to the maintenance industry

Cloud-based Internet of Things (IoT) and analytics services

Forewarned is forearmed in maintenance. Emerging technologies like the IoT can help product manufacturers build intelligent connected products with the ability to continually monitor their own condition and ensure that operational efficiency is above the threshold for optimum performance. The need for such analytics will lead to the creation of built-in or service-based offerings, which predict a dip in efficiency and perform root cause analysis to locate the components needing service or replacement.

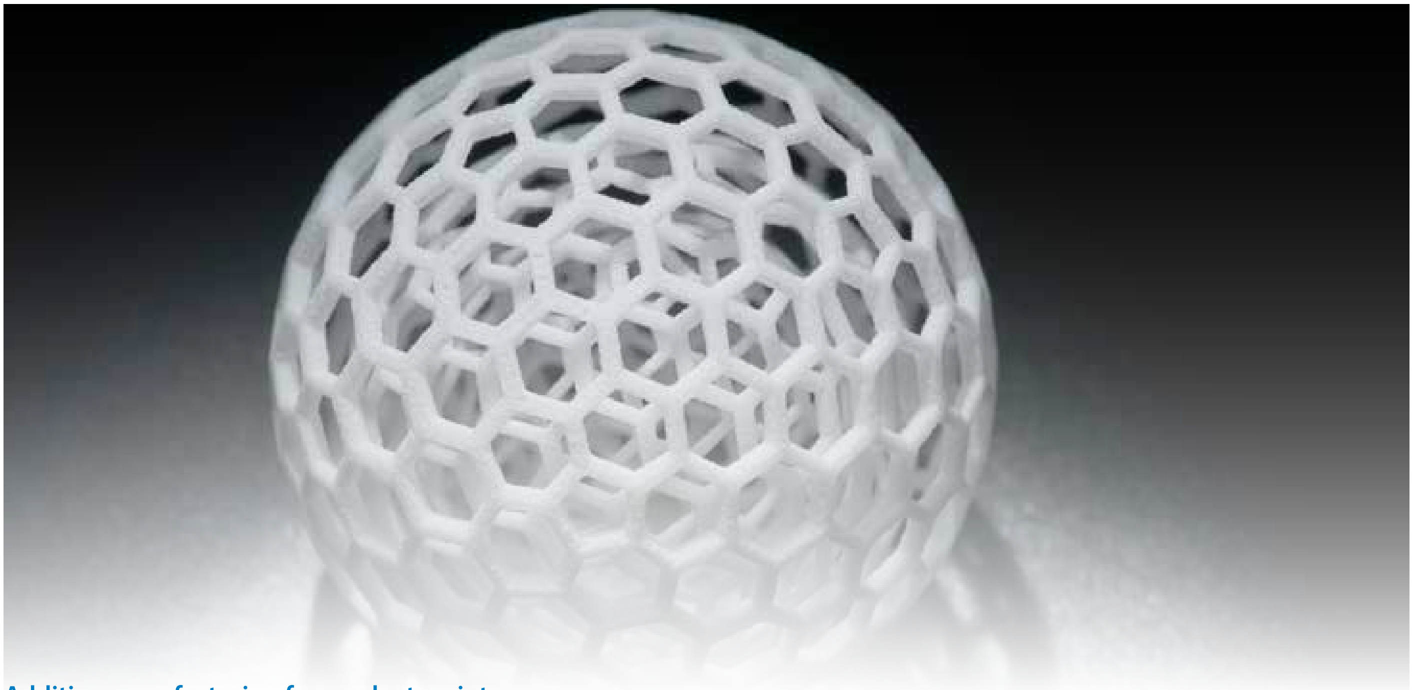
For example, in case of a food processing plant that operates two shifts a day, the only opportunity for maintenance is during non-working hours and holidays. A snag that halts production could mean wastage of a huge amount of in-process material, which occasionally, can result in further down time due to equipment cleaning and re-starting the affected manufacturing process.

A high degree of system reliability is required for such manufacturing operations and the ability to predict potential faults or breakdowns will undoubtedly provide valuable insights which will help save on time and resources. By using smart sensors and on-board electronics that can communicate with the manufacturer's cloud-based analytics system, the product vendor would be able to assess the working condition and service requirements of equipment in advance. Routine replacement of parts as per scheduled maintenance cycles, such as once in two years, can be avoided as long as the equipment functions at optimal levels. This would result in higher uptime of equipment and remarkable savings in maintenance costs.

Later, say at the end of 3 years of utilization, when it actually starts indicating some variation in the current consumption pattern the embedded sensors would be able to detect this anomaly and point out to the component showing signs of wear.

While this may not be an immediate concern under normal circumstances, based on condition data and usage pattern, chances are that after approximately two months this may start affecting the equipment's efficiency and result in higher energy consumption. Four months on it could start generating vibrations that may start damaging other components and lead to potential failure.

These kinds of insights produced by the combined use of operational knowledge, sensors, embedded electronics and analytics service, cloud based systems, could help unlock huge unused potential. In the example above, continuous monitoring and timely notifications generated by the system approximately two months ahead of time before observing a drop in efficiency enabled extended use of the component for an additional year.



Additive manufacturing for product maintenance

Additive manufacturing can help produce parts just in time at a place where you need it. In a normal scenario, an oil exploration ship that needs a component replaced while on a mission would have to return to a port for repairs. But with advanced manufacturing techniques, the ship can produce parts on-board by buying a license from the manufacturer to create a replica over a cloud based service and greatly reduce supply chain and inventory carrying costs. Most companies in the EPC (Engineering Procurement and Construction) sector derive substantial benefits from IoT as supply chain and inventory carrying costs constitute a major part of their expenses that can be done away with. Turn key projects executed by EPC companies like commissioning oil refineries, dams, bridges etc. can 3D print components needed at site instead of waiting for these parts to be procured and shipped via the company's preferred vendors.

Additive manufacturing leverages several unique technologies. Each additive manufacturing process varies in the way it deposits material to build a part.

But essentially, it follows a basic process of interpreting a 3D CAD model, constructing components by continuously depositing material in horizontal layers and fusing them together to build a whole part. A few promising advanced additive manufacturing techniques are 3D printing, laser sintering and stereo lithography.

Broadly, an additive manufacturing process has the following advantages:

1. Can produce parts on demand as it does not require molds, dies or preset tooling.
2. Involves no setup cost for tooling, hence can accommodate changes at no additional cost.
3. No minimum batch quantity; can manufacture even a single piece.
4. Does not require an elaborate production environment, and many types of equipment can operate in offices, homes or even in maintenance technicians' vans.
5. Can manufacture parts with different materials ranging from polymers and plastics to resins and metals.

These advanced manufacturing techniques not only impart the ability to produce parts where and when required but also largely eliminate the need for specialized skills.

Hence they are a versatile and acceptable solution for several maintenance scenarios.

Additive manufacturing allows production of parts on the go. Soon product vendors would sell 3D part specifications subject to appropriate digital rights, to allow legitimate customers and service technicians to buy/lease licenses for printing a certain number of copies in online marketplaces like app stores. This will build an ecosystem/marketplace where product vendors and value-added service providers could offer digital versions of component specifications either in standard designs or modified to suit custom needs.

In the earlier example, consider a scenario in which the technician attending to the food processing equipment's service request is equipped with additive manufacturing systems inside the service van. The technician could print parts before coming to the site or on arrival. This would eliminate the lead time of parts ordering and delivery, as well as significantly shrink sourcing costs. In effect, the only party involved in the supply chain and repair job is the service technician.

New business models will evolve as a result of technology evolution

Companies will be able to exploit the advantages of the latest technologies to adopt new business models built around deep analytical insights and new delivery mechanisms. This will shrink the organization's size in terms of staff and physical infrastructure, and thereby save cost. Products will no longer be physical objects alone, but also include a service component to comprehensively address end user needs. For example, the sale of washing machines may be replaced by the sale of garment washing services at a fixed cost and duration of say, 10 years.

Similarly, automobile companies will not sell cars alone, but rather, a complete mobility solution for several years, and include the cost of peripheral services such as maintenance and insurance in the price.

Such possibilities, which are entirely conceivable in the near future, will change the way in which organizations look at clients and provide services. In these scenarios, organizations would continually monitor assets, fine tune them over the network when needed, and keep customers posted. They might engage local empaneled service technicians to provide services, enabling them with information on service requests as well as equipment, such as 3D printers on which they could receive printing instructions for parts based on the analytics and alerts received on cloud infrastructure from the equipment installed at the customer's premises. Such a service model would not only allow the service provider to take timely action but also engage the customer in discussions to take feedback or sell additional products.

Compared to a conventional customer service supply chain, these new models will require significantly fewer people and lesser infrastructure to deliver similar or even superior services.

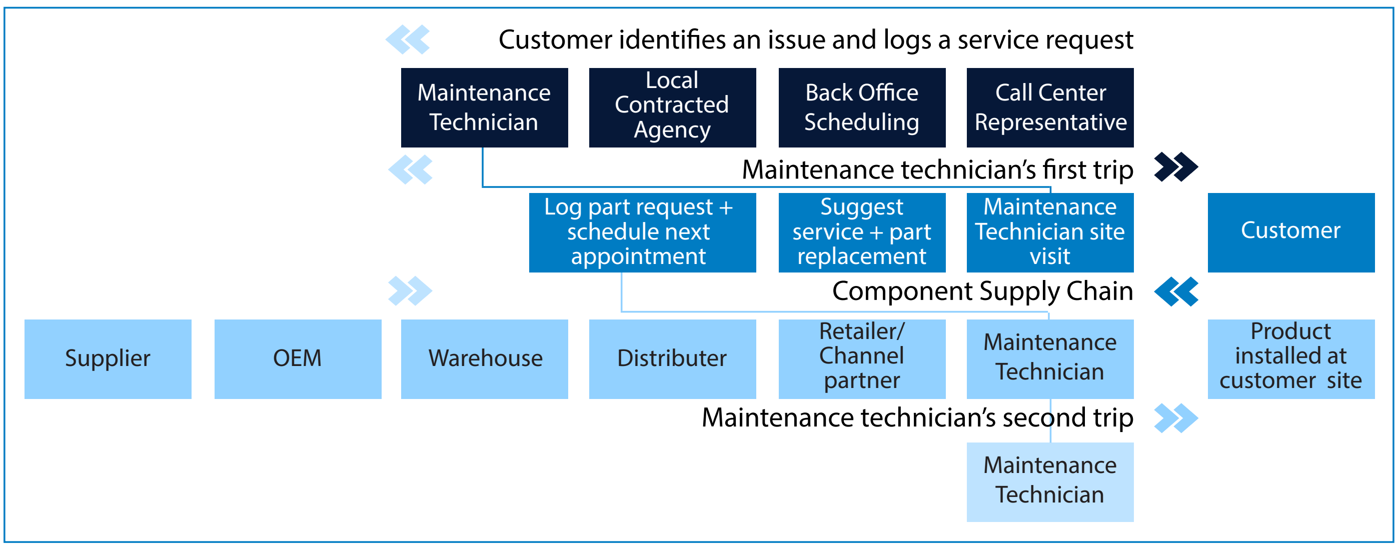


Figure 1: Conventional Customer Service and Supply Chain Scenario for a Service

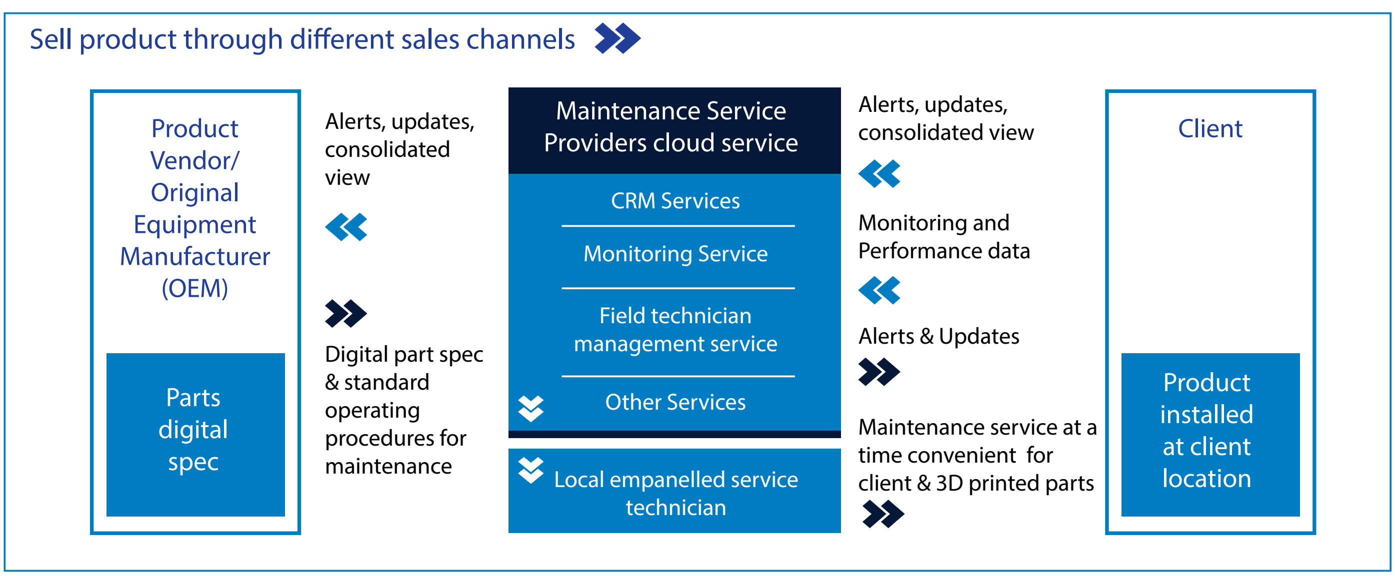


Figure 2: Futuristic, connected products talking to a cloud-based infrastructure to produce insights and a field technician who can fulfill the need based on an online service request

Challenges

While new products will be designed considering what IoT has to offer, a huge amount of existing assets needing maintenance will have to be retrofitted with devices to get insights. This may not always be straightforward due to:

1. Inadequate detailed technical knowledge about the equipment.
2. Selection of appropriate devices for data acquisition.
3. The difficulty in devising IT systems and cloud-based services for monitoring equipment not designed from ground up with monitoring integrated in the basic design.
4. The need for proven analytics and mathematical models to convert data acquired into insights.
5. Down time involved in retrofitting and monitoring assets before making them available for production.

Though additive manufacturing can produce complex intricate parts outside the capability of conventional manufacturing processes, it has its own drawbacks as well:

1. Certain components are still best produced by conventional manufacturing processes. Examples include:
    a. Very strong components, such as forgings, may require conventional manufacturing.
    b. Components that need very high surface finishes are yet difficult to produce by additive manufacturing.
    c. Certain materials, such as wood, can only be processed through conventional manufacturing processes due to their inherent properties/ limitations in printing.
2. Additive manufacturing requires component specifications with extreme details unlike conventional manufacturing processes. Product vendors will have to make significant investments to produce these specifications, before adopting additive manufacturing as a mode of component delivery.
3. Availability and cost constraints in procuring industrial grade additive manufacturing equipment.

Assets that are remotely located or operate in very harsh environments may have challenges in connecting with cloud-based services. Examples include deep sea oil rig equipment or mining equipment that operate hundreds of feet underground. Special connectivity solutions will have to be designed and implemented for such applications.

Conclusion

Business models will transform from merely selling products to offering an entire solution, complete with product, usage options such as leasing, and sundry business solutions, for a total cost of ownership till the end of product life. Product vendors will focus on their core strengths and build better products, relying greatly or even totally on ecosystem partners to provide additional services like maintenance, repair and other support functions.

Leveraging technologies such as IoT, analytics, sensing, additive manufacturing and others in new product design will both be the norm and a factor of success.

About the author

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With over 15 years of industry experience, Mitesh leads the Internet of Things (IoT) domain for the Manufacturing Innovation Initiative group. He works closely with clients and teams working on IoT programs, enabling development of merging technology implementations, Machine-to-Machine (M2M) communication, and emerging technologies. Mitesh has also worked in the areas of robotics and product development. Other areas that Mitesh focus on include enterprise application integration.

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