

Enablement of Internet of Things using Cloud Computing

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Abstract — Over the past few years value of data has been increased. More and more companies are coming out with the strategy to provide high value data including healthcare, weather, transportation, vehicles and electronic devices. This data is generated and stored in the servers. Internet of things is helping clients to generate data and then run analytics to provide relevant information. Internet of things supported by cloud computing can be an efficient combination which enhances the shared use of resources. There might be some challenges while integrating Internet of Things with Cloud. This paper showcases the building blocks of integration of cloud computing and Internet of Things along with the concerns.

Billions of smart devices are available and installed in our world today. These devices generate data and store in the centralized server. Insights from real-time devices and analytics using the data can deliver intelligence to power a Smarter Plant. Usage of Cloud computing to store or retrieve the data can be cost effective. Combination of Internet of things and cloud computing can boost the usage of applications such as smart vehicles, smart roads, smart cities etc.

Keywords — Cloud Computing, Internet of Things(IOT)

I. INTRODUCTION

The "Internet of Things," or IoT, is all around us, from heart monitor implants, to cars with tire-pressure sensors, to assembly lines with efficiency monitors. Any natural or man-made object that can be assigned an IP address and provided the ability to transfer data over a network is part of the Internet of Things. The IoT market represents a trillion dollar opportunity. Through Cloud and IOT, one enable enterprise and retail clients to provision services, subscribe to events/alerts and monitor SLAs for services.

Internet of Things architecture involves high usage of network as there are multiple sensors using the network to send the data to the centralized servers which can be on cloud. Sensor technologies are also becoming advanced to cater the cost and efficiency issues. The data sent by sensors has to be processed in such a way that it can be easily read and understood by the end users. Internet of things consists of sensors, network and centralized servers which can be in the form cloud. Cloud computing shall enable the organizations to use the shared resources such as servers, storage, data warehousing tools, analytical software etc. Cloud computing

with the combination of Internet of things shall enable administrators or end users to use the system on demand and that too anytime and anywhere

Multiple industries have already started working on Internet of things with Cloud computing. Vehicle manufactures and white goods manufacturers are excited about the opportunity to engage and even form a relationship with the end user. Historically the only time a consumer would interact with the manufacturer would be if something is broke. IoT present an opportunity to reverse this, and for the first time ever create a business model that drives positive brand engagement which includes reduced in the field service costs, innovative product design and the sale of related products and services. IoT gives White Goods a 'voice' and consequentially create a business model that drives positive brand engagement which includes reduced in the field service costs. It can drive cost out of the business through IoT enabled optimization:

- Improve after market service via 1st time fix service calls, predicative maintenance, improved warranty experience, and improved warranty modeling.
- Improved product design - by ingesting operational data, and by capturing user profiles we're able to understand how the machine runs, but also who is using it. That usage feedback loop drives faster iterations within product design, acts as an extended form of market research and we hypothesize will likely influence inventory levels and supply chain optimization.

It can generate new sources of revenue through the introduction of new products and services.

- Feedback from usage data will drive better market/product fit, faster.
- Manufacturers are able to utilize the connected appliance as a channel for engagement where 3rd party promotions can be delivered.
- Up sell/Cross sell is made possible- Manufacturers will have the opportunity to sell consumables, detergent, groceries, cooking classes are good examples.
- Predictive maintenance can trigger lead creation within a CRM system - no better lead than one where you know the product is breaking! This leads to repeat buyers, customers for life.

End user expectations are increasing day by day. With the internet of things combined with cloud computing, one can enable and check the things at his own. There are multiple opportunities in this space for example an end user buys an IOT appliance which needs to be setup easily. How it can be done. Devices should be turned on and user should download a mobile application which shall do the pairing of mobile device and IOT appliance. As soon as pairing is completed manufacturer shall get the real time update of information about newly added customer. There are multiple benefits to the manufacturers

- Huge value in 100% device registration and pairing with end user ID
- Lower warranty costs via predictive analytics
- Competitive differentiator
- New business opportunities via new service and product offerings
- Higher customer satisfaction, reduced cost
- Improved customer segmentation and satisfaction

End users are getting advanced appliances and premium services. There are benefits to the end users

- Improved use of appliances
- Ease of use promotes increased use and engagement
- Increased access to relevant services and promotions
- More contextual engagement with the Brand
- Proactive Incident Management

There is a huge benefit to the consumer electronics industry and end consumer. White appliances like washing machines, refrigerator, Microwave in the kitchen are connected to each other via local network such as wifi. These devices are also connected to the call center and to the manufacturer via internet. Data is transferred to the centralized servers via cloud computing. Now assume the value to the industry

- Warranty support. Reduce Warranty costs
- Field service support optimization – 1 visit fix

- Understand warranty history for more optimized warranty terms
- Predictive maintenance – Advance notification of potential failure, service annuity stream opportunities
- ‘x’ new Services
- Future Engagement
- Customer Loyalty
- Improved product design and usage

Now assume the value to the end user consumer who is worried about the maintenance

- Improved Value from Warranty
- Convenience of service – 1 visit fix
- Environmentally conscious through reduced energy consumption
- Peace of mind – reliable dependable product experience

There are three imperatives of Internet of things and cloud computing

- **Increase Revenue** - Create innovative products and services. Leverage operational analytics while enriching with analytics targeted towards the consumer to build new revenue streams
- **Reduce Cost** - Build and optimize dynamic value chains. Make use of operational device data to optimize existing systems while creating new enhanced processes to drive cost out of the business
- **Improve Engagement** - Provide differentiated innovative customer experiences. Grow customer base to both drive new revenue channels while retaining the most profitable clients and partners

Connected devices are growing at an exponential rate. Value derived from this connectivity drives massive monetary opportunity. Majority of value will be in B2B and B2B2C use cases. Putting it all together, IOT from chip to Cloud to App

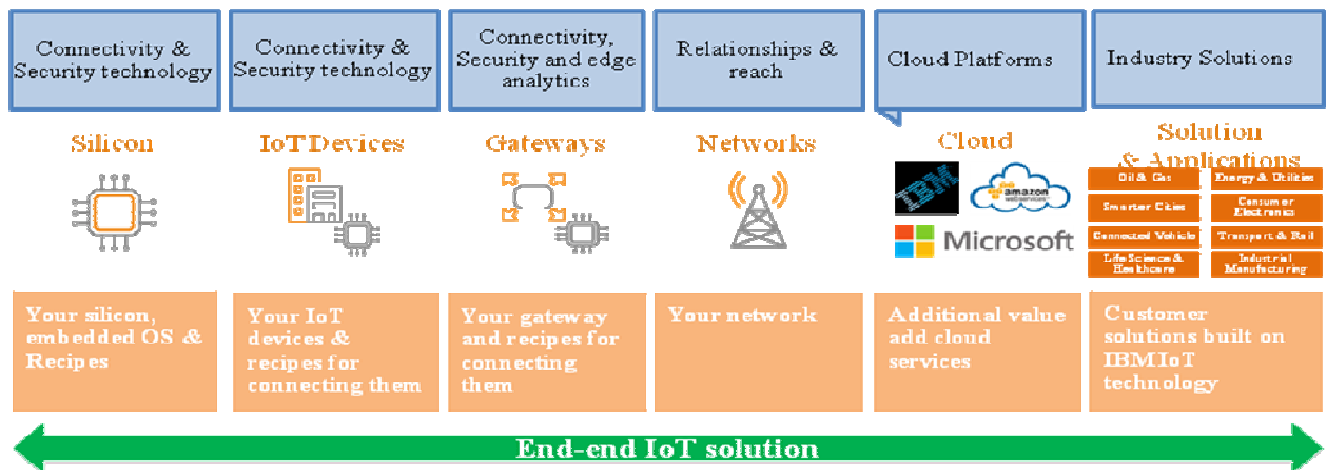


Fig 1. End to End IOT Solution

In this paper, our focal point is the integration of Cloud computing with Internet of things. Section 2 describes the importance of cloud computing whereas section 3 talks about Internet of things.

II. LITERATURE REVIEW

The combination of IOT and Cloud is depicted in multiple studies. A research article shows it as CloudIoT[3]. It is one of the best services user or provider can imagine. The quality is unmatched as end users are getting the information available anywhere and anytime using applications on mobile or portal on the personal computer..Integration of IOT and cloud is vital as both constitutes and gives the quality of service to the providers and end users.

When away from Home, stress related to the security of the home is common. Some other doubts like Did I switch off lights? Did the enable security alarm or CCTV? What are children doing? With Home Automation[1], One can get away of these qualms with single application configured in one's smart phone or tablet. One can not only view the status of integrated devices at home but also can control these devices. Samsung Electronics has assured that 90% of overall devices such as televisions, microwaves etc, it manufactured, will have sensors so that these can be internet enabled by 2017. All devices will be interconnected and can be accessed using remote application connected via a network(internet or intranet)[4].

Internet of things is becoming famous as manufacturers are looking to explore the technology to improve the quality of services to the end users. The correct picture of IOT is depicted when all the devices are not only interconnected with each other but also are connected with centralized servers so that support systems can be improved with right business intelligence applications [6].

Adoption of new technology or concept is always a challenge and in the case of cloud computing adoption, there are still some reservations. Various strategies and factors have

been identified which helps the organizations in adoption of cloud computing. Factors not only shows the technical aspects but also other functional and cost related aspects to identify the right Cloud computing environment. Some of the factors are Capital Expenditure required to use an application or infrastructure, lead time to enable the application or its related infrastructure, security related aspects or factors, availability of the application or infrastructure [5].

III. CLOUD COMPUTING

One of the many advantages of Cloud computing (CC) is the availability of established applications that have been used and tested by many businesses. It is much faster to deploy these applications online than using the old 'off-the-shelf' approach which took a lot of time and downtime to test, optimize and get going. Some of major advantages are

- Flexible in Pricing "Pay as one use"[10]
- Faster implementation time
- Virtualization of resources
- Ability to manage future scale up needs

Peter Mell & Timothy Grance *et al.* [7] stated in their study that Cloud computing helps organizations to evade upfront investments in infrastructure, and provide edge to deliver business projects. Organizations has the flexibility to start with less capital investments [8,9] and can scale up according to their needs for future expansions. Primary components of Cloud Architecture and shown in Figure 2.

- Five characteristics: on-demand self-service, broad network access, resource pooling, rapid elasticity, and measured service.
- Four deployment models: private clouds, community clouds, public clouds, and hybrid clouds.
- Multiple service models: Soft
- ware as a Service (SaaS), Platform as a Service (PaaS), and Infrastructure as a Service (IaaS)

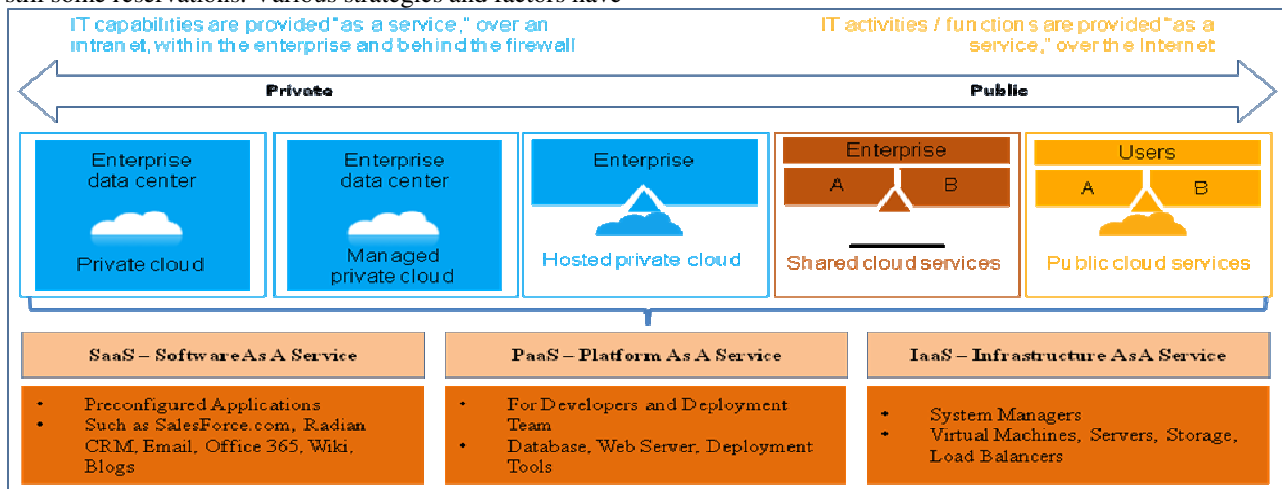


Fig 2. Cloud Computing architecture

Cloud Computing is offering multiple benefits to the Smart home owners [11]. As there is an increase in number of consumers of Smart phones or tablets, it is easy for these users to connect to server deployed on Cloud using internet. Some of the benefits of using cloud computing are

1. High Availability - Cloud offers high availability which can provide flexibility to the users to connect almost all the time. Almost all the cloud service providers are offering SLA(Netmagic Solutions, SimpliCompute : SLA)
2. Reduction in Upfront Investments - Instead of having own servers, cloud computing provides services to use the servers or applications thus reducing the upfront investments.
3. Safety of Data - Data gets accumulated at central location so safety is ensured. Apart from one central location, users can also opt for Disaster Recovery options
4. Analytics - Users can opt for keeping the for longer duration and can get the analytics done using the data to know the trends.
5. Flexible in Pricing - Cloud computing provides flexibility in payment & pricing as it offers "Pay as one use" model [10].
6. Faster implementation time - There are multiple cloud providers are available. One has to choose the right vendor and can access the infrastructure to support the applications in very less time.
7. Future Scale Up - Cloud computing is support by large pool of resources which provides the ability to manage future scale up needs. One can also scale down the requirement up to minimum level

IV. INTERNET OF THINGS

In 1999, IOT term was launched and that too was showcased as prospect of Internet which shall present everywhere in the form of networks. IOT is treated as a revolution which enables the network using multiple advanced technologies like sensors, Bluetooth or WIFI. IOT enables any device to connect to network and enables the wireless monitoring of these devices.

There are 3 Is in Internet of Things which makes the devices smarter.

1. Instrumented - Reduced cost of connecting IT to the physical world via ‘endpoints’ such as sensors, actuators, video cameras and embedded computers
2. Interconnected - Increasing ubiquity of Networks
3. Intelligent - Increased scale and sophistication of Stream and Predictive Analytics

As mentioned in figure 3, To Become Smart means to make sense out of Raw Data and present it the end users to make use of devices efficiently.

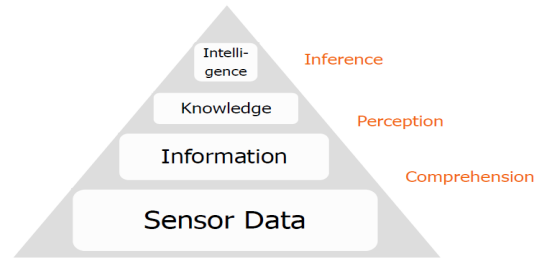


Fig 3. Knowledge Transformation

There are multiple examples of Internet of things and these examples are from multiple industries and are shown in below Fig 4.

	Banking	Healthcare	Automotive	Retail	Transport	E & U
Monetize	Cash replacement solutions Mobile Banking	Paid home care family services	Pay-per-drive car rental	Cash replacement Sensor enabled Loyalty cards	Paid Alerts to travellers Congestion charging	Pay-per-use energy
Optimize	Optimized Cash management	ER Bed Resource Mgmt	Component predictive replacement Fleet mgmt	Delivery and stock replenishment optimization Store layout optimization	Smart Cities Traffic mgmt Airport Management	Delay non-essential supply during peak loads
Extend	Banking the un-banked Biometrics Smarter Subsidies	Life style monitoring	In-car Movies, Music, Games Highly Automated Driving	Smart Vending Machines Delivery Lockers	Mobility Services	Smart home services
Control	Remote ATM Management Dynamic Authorization	Remote Hospital environment Mgmt	Remote Drive-train optimization	Store energy mgmt Store parking mgmt Dynamic price labels	Crowd mgmt Timetable mgmt Asset mgmt	Remotely control consumer devices

Fig 4. Examples of IOT

V. ARCHITECTURE OF INTERNET OF THINGS AND CLOUD COMPUTING

Building the Internet of Things using Cloud computing is critical activity. Specialized architectural skills are required to prepare the whole architecture which can fulfill all the aspects of integration of smart devices using Internet of things and cloud computing.

- A. Mobile application or desktop application - An Application which connects with the end user devices using Bluetooth or WIFI should be installed in mobile or desktop or smart phone.
- B. Web Server - A Server is required either to hosted on premise or On cloud. This server not only communicates to mobile application to facilitate the data but also interact with Smart devices using IP protocol.
- C. DB/Storage - A data base or storage is required to accumulate the data pushed by the sensors of the devices. User can maintain the data as long as one wish.
- D. Analytics - One can analyze the data stored in the database to know the patterns of the users.
- E. Reporting Server - This server generates the reports as per user format. Users can access the server and can download the reports.
- F. CoAP - Wireless protocols are required to enable interaction between devices. Multiple wireless protocols are available for example IEEE 802.11 Series, 802.15 Series, Zigbee, etc. Internet Engineering Task Force(IETF) has also come up with the protocol known as Constrained Application Protocol (CoAP) which is light weight. CoAP has been gaining grounds and has become the replacement of HTTP for IOT.
- G. Network - Availability of network connectivity is the major driver for integrating with IOT. Multiple networks such as broadband, Fiber or 3G/4G networks and then usage of IP enables connectivity.

H. Sensors- Electronics manufacturing organizations are working towards getting the devices enabled through sensors which can be used to generate the data and moreover multiple functions of these devices can also be controlled from remote location. These sensors(Eriksson J. 2011) are linked with IP which can be accessed and controlled. Currently there are 2 technologies for IP i.e IPv4 and IPv6. IPv4. IPv4 is used in managing data traffic in internet although addresses are getting exhausted. With IPv6, we can utilize the same technology for these kind of devices which can be used.

Multiple companies are working to provide solution for Internet of Things. IBM is one of the biggest players to provide multiple capabilities and benefits not only to the end users but also to the manufacturers as shown in Table 1.

TABLE 1. Capabilities and Benefits

Benefits	Capabilities
Real time data usage analytics	Leverage usage data to make better products and improve client engagement through analysis. Turn unpleasant experiences into memorable ones, earn repeat business.
Solutions to malfunctions delivered to the end user or to techs in the field	Reduce support calls by providing answers to the customer for self service, or distribute incident reports to field techs so only one visit is ever needed.
Enable near perfect Device Registration	Ease of use related to registration and the collection of end user information - Allow end users to easily register their devices & provide consumer/end user information
Device Management, Command and Control features	Deliver an engaging experience and deliver value via mobility. Command functions to control your device or appliance. Set up alerts, triggers – reboot and shut down.

Some of the used cases of consumer electronics and architecture is also shown in Figure

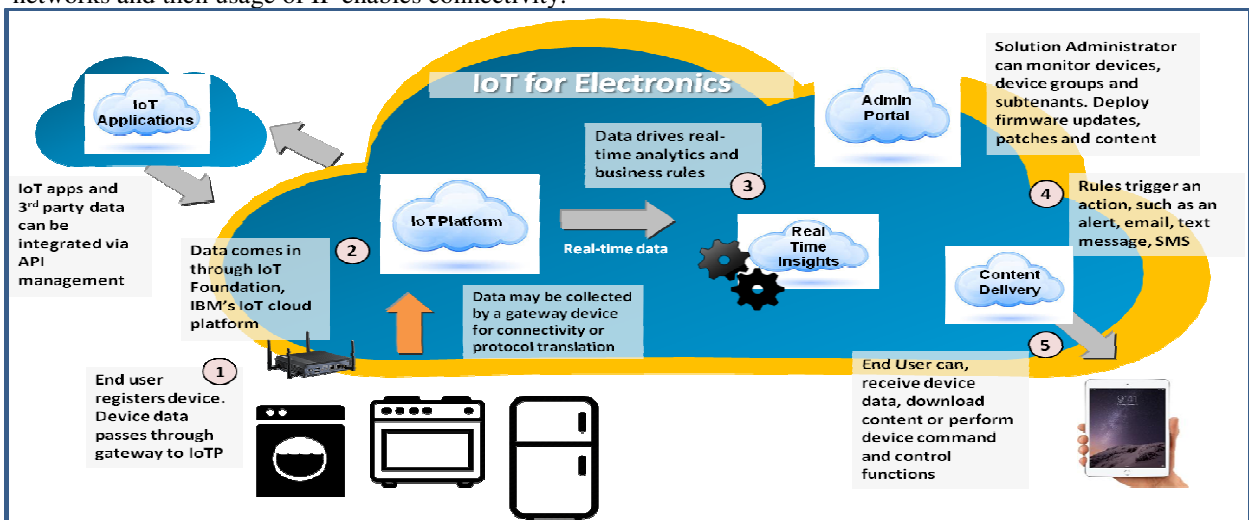


Fig 5. Architecture and Use Cases of IOT

VI. PROPOSED APPLICATION OR IMPLEMENTATION

Users should be comfortable to use the IOT solution proposed by organizations. We are taking an example of using IOT in smart homes. There are multiple factors a user considers while adopting any new application or solution.

TABLE 2. Criterion

Criterion	Description
Cost	Today users adopt the applications or solution which have minimal or no cost.
Quality of Service	Multiple payment options such as online payment or pay as you go should be configured to ease the transactions
Safety and Security	Users should be able to see its IOT devices only. Hacking or other intruders should be restricted.
Convenience	Configuration of multiple devices should be made easy. Agility in the solution should be the main component to give handiness.

Today customers are using smart phone mobiles in their daily lives to make use of multiple things such as Mobile Banking, Online Retail using E Commerce Companies etc. Mobile users are using mobiles based on multiple platforms like Google Android, Microsoft Windows & Apple Platform. Complexity of building an application is very high due to multiple platforms with multiple versions.

We are suggesting an application or solution which can be used by multiple users covering the following aspects: implications for practices and procedures, security requirements, training requirements, and continuous improvement. This mobile application should work on multiple mobile platforms. Application should be able to connect to the local devices as well as servers which are installed in cloud.

Every Mobile manufacturer has provided the development platform to build an application which can be installed on their respective devices.

1. Apple provides an Xcode SDK (<http://developer.apple.com/devcenter/ios>) including an interface builder, an iPhone simulator and development environment;
2. Google provides Android SDK comes as an eclipse plug-in, and includes a software emulator;
3. Microsoft provides a specialized version of the Microsoft Visual Environment;

More and more cities are proposed to be part of Smart Cities projects executed in multiple countries. People have also shown interest in making or building the smart homes. With the use of technology in consumer electronics devices such as television, microwave, Air Conditioner, electrical devices etc, one can control the multiple features of these devices while staying away from their homes.

An application can connect to the devices installed at home using the central server deployed in cloud and connected to the electronics sensors built in the electronics devices. Mobile application shall send the message to operate functions with

the help of server in cloud. Mobile application can cover the installation and linking any new consumer electronics using cloud. Below is the architecture for IOT.

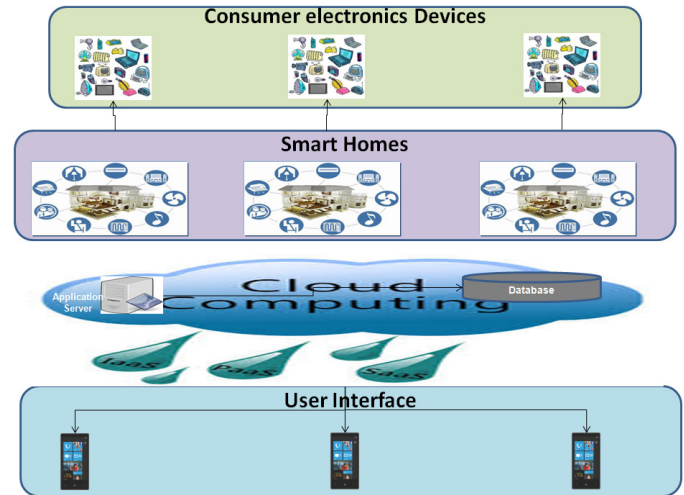


Fig 6. Architecture

VII. CONCLUSION

Although Cloud computing and Internet of Things (IoT) are two different technologies yet both can interact with each other to provide advanced and easy approach to analyze and view the picture. A study has been conducted to evaluate the integration of Internet of Things and cloud computing to improve the quality of service.

Cloud Computing and Internet of things provides the best combination in the future. It will be the great jump to promote the network of network. This integration will unlock new corridor for end users, manufacturing organizations, IT companies and research associates. This integration can enable anything to be Smart such as Smart homes, Smart vehicles, Smart Cities, Smart Banking, Smart Healthcare etc. However there are some challenges to be addressed for example Connecting with plethora of devices, Capturing massive volumes of device data at speed, Analyzing big data in real-time and with location, Automating response without complex coding, Integrating and sharing device data and services

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