Unleashing the Power of Cognitive Internet of Things
Global business leaders are actively seeking to harness the transformative capabilities of the Cognitive Internet of Things (CIoT). The explosion of enterprise digitization has arisen from the massive increase in data stemming from human-to-device interactions. This digitalization dynamic provides consumers with greater market influence in terms of product and service choices, pricing and expectations. In turn, companies must continually rethink and reinvent their business models and product offerings to maintain speed, agility and relevance. CIoT drives the next generation of data analytics and technical capabilities. CIoT infuses intelligence and decision making into the physical world to continually transform businesses and enhance the human experience in real-time.

This report explores several use cases that highlight the power and capabilities of CIoT. These emerging trends demonstrate how today’s companies can offset constantly fluctuating market dynamics, create competitive advantages, improve customer relationships, and deliver quantifiable value to both the top and bottom lines. Also provided, is an overview of how CIoT can be applied across the enterprise from both a business and operating model perspective.

As technology evolves, CIoT will become smarter and faster. CIoT will take advantage of the current proliferation of APIs (application program interfaces) and the future expansion of open source systems. The evolution of CIoT will enhance the ability of companies to draw closer to their customers, as well as create new and differentiated product and service offerings.
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Why Cognitive IoT? Why now?

The multi-faceted power of Cognitive IoT

How to apply Cognitive IoT

The future of Cognitive IoT

Are you ready?
Cognitive IoT is a disruptive force. Cognitive IoT drives radical changes in the way companies organize and manage their business.

<table>
<thead>
<tr>
<th>Drivers</th>
<th>Trends</th>
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</thead>
<tbody>
<tr>
<td><strong>Customer</strong></td>
<td><strong>Trends</strong></td>
</tr>
<tr>
<td>Individualized end-products (production quantity of 1)</td>
<td>Consumer expectations across service, quality and experience driving need for a deeper level of customer intimacy</td>
</tr>
<tr>
<td>Individualized pricing</td>
<td>Consumer influence</td>
</tr>
<tr>
<td><strong>Industry/ Market</strong></td>
<td><strong>Trends</strong></td>
</tr>
<tr>
<td>Increased global competition</td>
<td>Adoption of new connected devices</td>
</tr>
<tr>
<td>Need for resource optimization</td>
<td>Search for new revenue streams (e.g. services)</td>
</tr>
<tr>
<td><strong>Technology</strong></td>
<td><strong>Trends</strong></td>
</tr>
<tr>
<td>Cheaper sensors and processing</td>
<td>Ability to secure sensitive data &amp; intellectual property</td>
</tr>
<tr>
<td>Advanced analytics on data in motion &amp; automated decisions</td>
<td>Use of flexible robots, 3D printing, and cognitive</td>
</tr>
<tr>
<td><strong>Products</strong></td>
<td><strong>Trends</strong></td>
</tr>
<tr>
<td>Compressed product lifecycle</td>
<td>Continually changing consumer preferences</td>
</tr>
<tr>
<td>Need for greater speed to market</td>
<td><strong>Trends</strong></td>
</tr>
<tr>
<td>Access to data from products in service; enabling enhancements, quality improvements, and optimization of cost to serve</td>
<td>Need for anticipation of unforeseen market conditions, events, and challenges</td>
</tr>
</tbody>
</table>
New partnerships and ecosystems are forming as entire industries undergo transformation in response to these dynamics.

What leaders are saying:

54% Fear competition from other industries ¹

75% S&P 500 companies will be removed from the index by 2027 at current churn rate*²

50% Agree that a having a "broad ecosystem of partners" is important during IoT vendor selection³

80% IoT smart device vendors in China will be eliminated through competition by 2018⁴

Market observations:

Developed joint venture between ABB, Bosch, and Cisco that provides a open smart home platform⁵

Launched Analytics & Innovation division to develop an end-to-end platform for predictive diagnostics with Uptake⁶

Launched social innovation initiative that will offer IoT solutions in Industrial, Automotive, and Healthcare industries⁷

GE Digital is aiming to be a top 10 software company by 2020⁸. They want to become the next Apple, Amazon, Google for the Industrial Internet⁹

* – The average lifespan of a company on the S&P 500 has decreased from 90 years in 1935 to 18 years today.
Data is accelerating in volume, variety, and complexity. Traditional analytics solutions cannot fully exploit its value.

Huge amounts of complex data are available, but only a fraction of it is being utilized.

**2.5PB**

of unstructured data from 1 million customers is stored by Walmart every hour

0.5%

of world's data being analyzed (2012)

Limitations of traditional data analytics solutions in today’s global data landscape.

- Addresses predefined problems but cannot adapt to new problem domain
- Provides accurate and definitive answers but cannot handle ambiguity or grey areas
- Handles structured and unstructured information with known semantics – thus cannot make use of data from new and varied sources
- Interacts in formal digital means (e.g. commands, screens) with human – thus limits the engagement of end user

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* – Petabyte which is equal to $10^{15}$ bytes of data
Cognitive IoT represents the next generation of data analysis capabilities.

**Provides a competitive advantage**

By establishing a richer consumer experience, delivering deeper consumer insights, and adapting to pricing challenges

**Offsets constantly changing market dynamics**

By extending the product lifecycle, optimizing cost to serve, and continually responding to changing consumer preferences

**Delivers quantifiable value**

By augmenting human effort, improving insights and efficiency, and optimizing processes
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Are you ready?
The multi-faceted power of Cognitive IoT is:

**In Context**
Creating a personal and consumable experience by understanding the individual human element in the context of structured and unstructured data.

**In Real-Time**
Responding dynamically to chronic, multi-dimensional, and/or time sensitive problems.

**Intelligent**
Applying adaptable machine learning techniques to interconnected physical device data, patterns, and trends.

**Instrumented and Interconnected**
Marrying instrumented and interconnected data with unstructured data (e.g. Twitter®, Facebook®, text, email, voice).
Cognitive IoT delivers deeper insights that create a richer consumer experience.

CIoT puts the connected home in context by marrying instrumented and interconnected data with unstructured data such as voice, text, news articles, video feeds, social content, and comparable home data.
Cognitive IoT extends product life cycles by continually learning from, and responding to, consumers.

Cognitive IoT (CIoT) applies adaptable machine learning techniques to interconnected physical device data, patterns, and trends. Rather than being explicitly programmed, Cognitive systems learn from interactions with humans and their experiences with their environment. They are not deterministic, they are probabilistic\(^\text{12}\).

A wearable becomes a personal fitness coach…

**Marries User’s Input with Vital Sign Data**
- Collects living data from IoT wearable devices.
- Collects user defined data such as weight, age, health concerns.

**Generates Insights**
- Uses probabilistic models rather than deterministic models.
- Learns over time

**Suggests Personalized Care**
- Provides suggestions based upon user goals to tailor workouts, alerts, and provide coaching.
- Enables natural language conversations.
Cognitive IoT solves chronic and time sensitive problems. It provides dynamic responses in real-time to ever-changing situations.

*Helping people respond faster and more effectively when severe weather strikes…*

1. While driving, Joe receives a text alert from his weather app indicating that a previously issued thunderstorm watch has just been upgraded to a tornado warning.

2. The CIoT solution **RECOGNIZES** the text alert, uses GPS to determine whether Joe is in the path of the storm, estimates how much time he has before he is impacted by the storm, and **MAKES RECOMMENDATIONS**.

3. The CIoT solution **ANALYZES** traffic patterns and **REROUTES** Joe back to the soccer field location to pick up his kids.

4. After picking up his kids, the CIoT solution **DETERMINES** Joe cannot make it home in time and **SUGGESTS** a safe place to pull off and wait out the storm.

5. Once Joe is safe, the CIoT solution **AUTOMATICALLY NOTIFIES** other family members in the area that there was a severe storm and that he is safe.

6. The CIoT solution checks Joe’s calendar and **AUTOMATICALLY RESCHEDULES** appointments as necessary.
Cognitive IoT increases sales. Cognitive IoT understands the human element in the context of structured and unstructured data.

Jane Smith
Guest at mall restaurant

- CIoT engines perform social listening for preferences
- Monitors inventory, weather, and buying patterns
- Determines the promotion price for individuals
- Engages in conversation with users via app

1. It is an unseasonably warm day. Jane is finishing up her lunch break and tweets that she enjoyed her salad at a mall restaurant.

2. The restaurant’s CIoT engine “listens” to Jane’s social media post and uses instrumented data to determine there is an opportunity for the restaurant to sell remaining fruit inventory that is nearing expiry date.

3. The CIoT engine determines an appropriate deal for Jane based upon her buying patterns, the warm weather, and product costs. The engine sends a message to Jane about a coupon for a frozen fruit smoothie.

4. Realizing she could use an afternoon pick-me-up, Jane engages in a conversation with the CIoT engine and orders the frozen fruit smoothie for 15% off.

5. The CIoT engine provides a notification when the frozen smoothie is ready for pick up.

Sales increase during a period when they otherwise may not have
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Are you ready?
Cognitive IoT delivers quantifiable value and competitive advantage.

The 2016 U.S. women’s cycling team used instantaneous insights from instrumented bicycles. Coaches better understood rider power and implemented game changing pacing and switching decisions in real-time.

The United States won its first medal of the track cycling world championships\textsuperscript{13}
In a business model context, Cognitive IoT is an enabler for companies to deliver differentiated service offerings.

Hi, John. Thank you for your loyalty to our airline. Due to poor weather, your flight to Reagan Airport is delayed 6 hours.

- CIoT engine

If you don’t mind driving 1 hour, I can get you to Dulles Airport, getting to Washington D.C. on-time.

- CIoT engine

Yes, please make the arrangements.

- John

Head toward Gate D1. On your way, you can grab sushi with this 50% off coupon. Once you touchdown at Dulles Airport, please visit Hertz to pick up your vehicle.

- CIoT engine

Enhancing loyalty programs and creating dynamic commercial models…

A CIoT app responds dynamically to a time sensitive problem using instrumented and connected aircraft IoT data. The app monitors delays, routes, and air traffic and suggests alternative flights based upon a deeper understanding of the consumer and their preferences. The CIoT app then executes actions based upon the user’s input.
In an operating model context, Cognitive IoT directly impacts the top and bottom line by operating as a system-of-systems.

Unstructured Data  Disparate Data  Structured Data  External Data

CloT initially functions as a command center; providing recommendations that improve insights and efficiency…

...and ultimately works as a control center, augmenting human effort and continually optimizing processes and costs.
Using Cognitive IoT, companies can more effectively optimize costs and deliver greater value\(^\text{15}\).

### Productivity

<table>
<thead>
<tr>
<th>Metric</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Business Process Execution</td>
<td>“Doing the same thing, or more, with less”</td>
</tr>
<tr>
<td>Plant Capacity and Utilization</td>
<td></td>
</tr>
<tr>
<td>Cost to Serve</td>
<td></td>
</tr>
<tr>
<td>Rework Cost</td>
<td></td>
</tr>
<tr>
<td>Yield Percentages</td>
<td></td>
</tr>
<tr>
<td>Energy Costs</td>
<td></td>
</tr>
</tbody>
</table>

### Efficiency

<table>
<thead>
<tr>
<th>Metric</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Order-to-Delivery Time</td>
<td>“Doing the same, or more, faster”</td>
</tr>
<tr>
<td>Forecasting &amp; Planning Cycle Time</td>
<td></td>
</tr>
<tr>
<td>Cash-to-Cash Cycle Time</td>
<td></td>
</tr>
<tr>
<td>On Time Delivery %</td>
<td></td>
</tr>
<tr>
<td>Replenishment Time</td>
<td></td>
</tr>
</tbody>
</table>

### Effectiveness

<table>
<thead>
<tr>
<th>Metric</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Touch less Orders</td>
<td>“Doing the same, or more, with greater value”</td>
</tr>
<tr>
<td>Customer Satisfaction</td>
<td></td>
</tr>
<tr>
<td>Forecast Accuracy</td>
<td></td>
</tr>
<tr>
<td>Return on Assets (ROA)</td>
<td></td>
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<tr>
<td>Return on Capital Allocation</td>
<td></td>
</tr>
<tr>
<td>Available to Promise</td>
<td></td>
</tr>
<tr>
<td>Production Schedule Variances</td>
<td></td>
</tr>
</tbody>
</table>

自动化减少了工作步骤；流程不断优化以减少成本。实时客户数据被应用来提升在运营中的价值。

\(^{15}\) - 选择指标定义位于注释部分
Cognitive IoT utilizes adaptable models fueled by machine learning. CIoT grows and changes when exposed to new data.

These adaptable models allow companies to create optimal economic value from a variety of factors that are interdependent.
Cognitive IoT creates synergy across operational silos and aligns process execution to customer demands and expectations.

Illustrative End-to-End Process
Process scenarios are further optimized using data and insights from systems associated across the entire spectrum of the process.

| Available to Promise | Using anomaly data, real-time customer demand, and environmental data to better align the committed and actual date with the requested date. |
| Put Away Strategy | Connected material handling machine data, spatial and location data, as well as existing product data are combined to optimize the existing rules and policy (e.g. LIFO, FIFO) for inventory storage. As an example, products may be put away relative to expiration and sorted/shifted for specific customer tier and/or current inventory level. |
| Production Route Determination | Augmenting APCs* with machine data, energy consumption, customer segment & demand, fault & anomaly data, and sales campaign data to sequence and schedule production processes and routes as well as respond quickly to changes when necessary. |
| Safety Stock Planning | Optimize safety stock levels at a more granular level with the use of additional dependent system information from both the vendor and customer. As an example, WMS/TMS system data for on time delivery % and warehouse safety stock may be incorporated with customer specific demand at store level. |

* – APC denotes advanced process control
Companies can benefit by applying Cognitive IoT to process scenarios across all functions of the enterprise.

<table>
<thead>
<tr>
<th>Enterprise Functions</th>
<th>Example Processes*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Business Finance</td>
<td>• Fixed Asset Accounting</td>
</tr>
<tr>
<td></td>
<td>• Profit Improvement</td>
</tr>
<tr>
<td>Demand, Supply, and Production Planning</td>
<td>• Campaign sequencing</td>
</tr>
<tr>
<td></td>
<td>• Planning parameters</td>
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<tr>
<td>Inventory Management</td>
<td>• Inventory monitoring</td>
</tr>
<tr>
<td></td>
<td>• Promotion impacts</td>
</tr>
<tr>
<td>Environmental, Health, and Safety</td>
<td>• Emissions monitoring</td>
</tr>
<tr>
<td>Maintenance &amp; Reliability</td>
<td>• Maintenance notifications</td>
</tr>
<tr>
<td></td>
<td>• Maintenance planning</td>
</tr>
<tr>
<td>Manufacturing</td>
<td>• Energy management</td>
</tr>
<tr>
<td></td>
<td>• Production campaigns</td>
</tr>
<tr>
<td>Order / Invoicing</td>
<td>• Transportation planning &amp;</td>
</tr>
<tr>
<td></td>
<td>management</td>
</tr>
<tr>
<td>Quality Management</td>
<td>• Audit</td>
</tr>
<tr>
<td></td>
<td>• Line samples</td>
</tr>
<tr>
<td>Shipping &amp; Receiving</td>
<td>• Bonded warehouse strategies</td>
</tr>
<tr>
<td></td>
<td>• Tank farm management</td>
</tr>
<tr>
<td>Warehouse Management</td>
<td>• Put-away strategies</td>
</tr>
<tr>
<td>* – Not Exhaustive</td>
<td></td>
</tr>
</tbody>
</table>

*企业功能

<table>
<thead>
<tr>
<th>企业功能</th>
<th>示例流程*</th>
</tr>
</thead>
<tbody>
<tr>
<td>商业金融</td>
<td>• 固定资产会计</td>
</tr>
<tr>
<td></td>
<td>• 利润改善</td>
</tr>
<tr>
<td>需求、供应、生产和生产策划</td>
<td>• 营销活动 sequencing</td>
</tr>
<tr>
<td></td>
<td>• 存货监控</td>
</tr>
<tr>
<td>库存管理</td>
<td>• 排放监控</td>
</tr>
<tr>
<td>环境、健康和安全</td>
<td>• 员工健康监控</td>
</tr>
<tr>
<td>维护与可靠性</td>
<td>• 维护通知</td>
</tr>
<tr>
<td>制造</td>
<td>• 能源管理</td>
</tr>
<tr>
<td>订单/开票</td>
<td>• 运输规划与管理</td>
</tr>
<tr>
<td>质量管理</td>
<td>• 审计</td>
</tr>
<tr>
<td>航运与接收</td>
<td>• 带结仓库策略</td>
</tr>
<tr>
<td>仓库管理</td>
<td>• 水箱管理</td>
</tr>
<tr>
<td></td>
<td>• 插入策略</td>
</tr>
<tr>
<td></td>
<td>• 拆箱策略</td>
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* — 不详尽
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Are you ready?
Cognitive IoT APIs will grow faster and smarter; leveraging the overall burgeoning API economy and evolution of capabilities.

*Example* IBM Cognitive IoT API capabilities

- **Question and answer**: Direct responses to users inquiries fueled by primary document sources.
- **Speech to text**: Provides highly accurate, low latency speech recognition capabilities.
- **Concept insights**: Locate relevant documents that may not directly mention your query.
- **Machine translation**: Translate text from one language to another.
- **Personality insights**: Personality insights to engage users on their own terms.
- **Message resonance**: Communicate with people with a style and words that suits them.
- **Concept expansion**: Maps euphemisms or colloquial terms to more commonly understood phrases.
- **Relationship extraction**: Intelligently finds relationships between sentences components (nouns, verbs, subjects, objects, etc.).
- **Visualization rendering**: Graphical representations of data analysis for easier understanding.
- **Text to speech**: Synthesizes natural-sounding speech from text.
- **Tradeoff analytics**: Helps make better choices under multiple conflicting goals with smart visualizations and analytical recommendations.
- **Visual recognition**: Analyzes the visual appearance of images or video frames to understand what is happening.

*Not Exhaustive*
As Cognitive IoT matures, it’s impact will shift from producing insights to fixing problems, to automatically resolving problems on its own.

“By 2018, half of all consumers will interact with cognitive-based services on a regular basis.”
- IDC Market Analysis Perspective 2015

### Understanding, Reasoning, and Learning
- Processing unstructured data
- Natural language processing
- Machine learning
- Text analytics
- Video and image analytics
- Root cause analysis from disparate data sources
- Smart robots
- Cyber physical systems
- Autonomous vehicles
- Vocal and facial emotion recognition
- Trade-off analysis

### Healing and Fixing
- Smart Advisors
- Self-healing machines
- Cyclical knowledge base creation
- End-to-end automation
- Commercial and maintenance drones
- Virtual personal assistants
- Synthetic genomics

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Cognitive IoT will increase the adoption of B2B2C business models.

Forward looking view*

- Smart Homes
- Wearables
- Smart Factory
- Asset Management
- Cognitive Car
- Smart Parking

B2B2C connects the suppliers, manufacturers, distributors and consumers together¹⁸

**B2B2C**: manufacturer who is the supplier of finished products or semi-finished material

**B2B2C**: agent acting as the seller who connects the business and the consumer

**B2B2C**: ordinary consumers/buyers

* – Not an exhaustive list of examples
Using Cognitive IoT capabilities, companies will expand sharing economy models to reduce inefficiencies and excess capacity.

The *sharing economy* is generally referred to as “economic and social systems that enables shared access to goods, services, data and talent. These systems take a variety of forms but all leverage information technology to empower individuals, corporations, non-profits and government with information that enable distribution, sharing and reuse of excess capacity in goods and services.”

---

**Current**

- **Company A**
  - 70% capacity
  - 85% capacity
  - 50% capacity

- **Company A**
  - 70% capacity
  - 85% capacity
  - 50% capacity

- **Company B**
  - 50% capacity
  - 85% capacity
  - 50% capacity

**Future**

- **Company A**
  - 85% capacity

- **Company B**
  - 90% capacity
  - 90% capacity

Rapid prototyping, fabrication, and assembly or multiple parts from numerous companies

3-D Printing for on-demand custom items/parts
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Are you ready?
Key questions to understand before getting started with Cognitive IoT.

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<tr>
<th>Why are we doing this?</th>
<th>What capabilities do we need?</th>
<th>Where are we today?</th>
<th>How will we get there?</th>
<th>Who will be responsible?</th>
</tr>
</thead>
<tbody>
<tr>
<td>What is the business value of applying CIoT?</td>
<td>Do you have appropriate skills (e.g. data scientists) to pull this off?</td>
<td>Has an assessment of the status quo as a reference for future goals been completed?</td>
<td>What is the entry point model or process for CIoT?</td>
<td>Who will sponsor at an executive level to ensure commitment and resource availability?</td>
</tr>
<tr>
<td>What are the motivations, constraints and complications?</td>
<td>Is the technology platform in place to support?</td>
<td>Is the organization willing to think differently?</td>
<td>What campaigns and organizational changes are needed to drive adoption of the new services and capabilities?</td>
<td>Will the business support this?</td>
</tr>
<tr>
<td>Are there industries that are ripe for disruption?</td>
<td>What ecosystem partners do we have and need?</td>
<td></td>
<td>Are strategic partnerships needed to help drive execution?</td>
<td></td>
</tr>
</tbody>
</table>
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15. Metric definitions come from IBM’s benchmark wizard which is part of the IBM Institute for Business Value – http://www-935.ibm.com/services/us/gbs/thoughtleadership/

The customer order cycle (order-to-delivery time) begins when the customer places an order and ends when the product/service has been delivered to the customer.

Forecasting & planning cycle time is the time required to develop a reasonably accurate and/or acceptable forecast and business plan.

Cash-to-cash cycle time is the number of days between paying for raw materials and components and getting paid for a product. It is calculated as the number of inventory days of supply plus days of sales outstanding minus the average payment period for materials.

Replenishment time is the time taken between an item being out of stock and the time inventory is received and re-stocked.

Touch-less orders means to the extent possible, eliminating human error and bad data while putting into place supply chain processes that are automated from end-to-end.

Customer satisfaction is defined as the percentage of customers claiming to be satisfied in the most recent customer survey (assuming this data is collected).

Return on Capital Allocation, also defined as return on invested capital is defined as net operating profit after taxes by capital invested

16. MQTT is a machine-to-machine (M2M)/"Internet of Things" connectivity protocol. It is useful for connections with remote locations where a small code footprint is required and/or network bandwidth is at a premium. For example, it has been used in sensors communicating to a broker via satellite link, over occasional dial-up connections with healthcare providers, and in a range of home automation and small device scenarios. (MQTT.org)


18. Journal of Electronic Commerce in Organizations, 10(3), 1-12, July-September 2012
