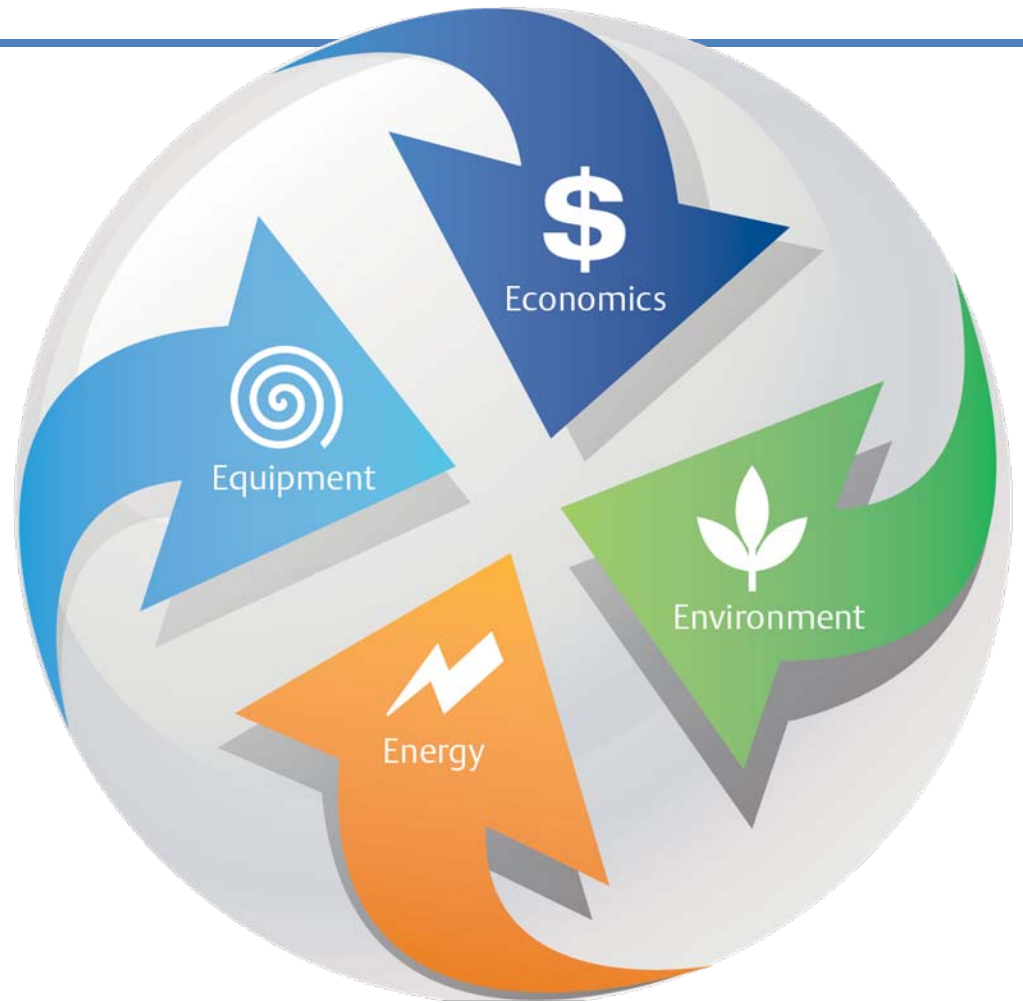# Unlocking the Potential of Embedded Electronics

John Wallace
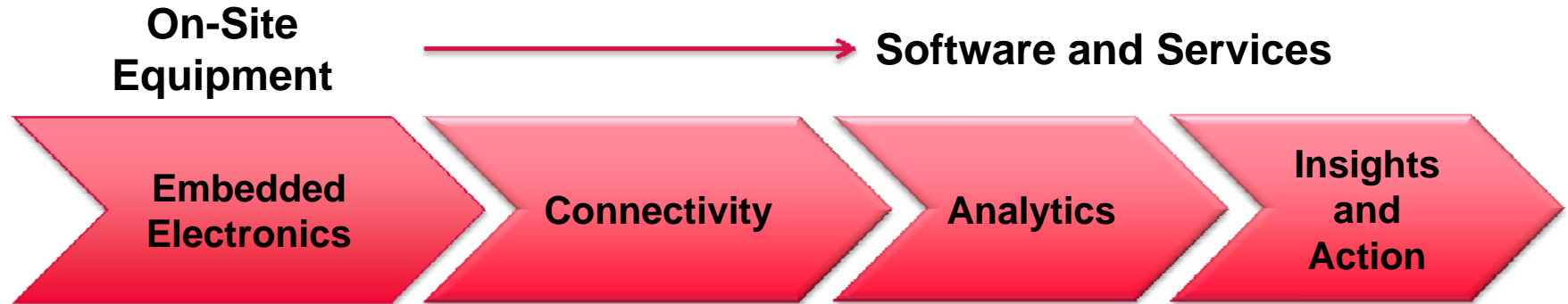*Emerson Climate Technologies Retail Solutions*

Discussion Topics

Note: This information was presented as a panel discussion at AHRI Expo 2015. This presentation will provide a summary of the discussion from the panelists.

- Background info

- What's the problem?

- Examples from other industries

- Connecting the dots

Electronics Framework for Value Creation

On-Site Equipment → Software and Services

| Embedded Electronics | Connectivity | Analytics | Insights and Action |

- **Better control**
- **Optimization**
- **Diagnostics**
- **Asset mgmt.**

- **Remote analysis**
- **Site "visibility"**

- **Hidden insights**
- **Performance analysis**
- **Prioritized actions**
- **Planning**

"Perfect Storm" of Industry Trends Unlocks Opportunities to Create Value

$

Action (Not Data) Creates Value

Connectivity

IOT

M2M

FDD

Internet of Things
The interconnection of uniquely identifiable embedded computing devices within the existing Internet infrastructure[1]

Machine to Machine Communications
Technologies that allow systems to communicate with other devices[1] (compressor to EMS, EMS to Cloud, etc.)

Fault Detection and Diagnosis
Algorithms detect potential failures in equipment generally using existing "control" sensors

1. Wikipedia

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Panel Discussion at AHRI Expo Discussed Impact of Electronics and Connectivity

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(ACCA)

George Hernandez
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Equipment On-Board Diagnostics

- **Not a new technology — automotive industry**

- **Individual OEM's have proprietary systems for years**

- **Industry "Futures Committee" recommendation: April 2014**

- **ACCA Board of Directors petitioned AHR — Sept. 2014**

Why?

- **Technology exists: today's equipment more sophisticated; has more electronic features**

- **Contractor complexities: work on multiple OEM systems**

- **Efficiencies and cost savings all around:**
  - Contractors — time in field lessened; better diagnostic/prognosis tools and capabilities
  - Distributors — warranty issues; better component interoperability
  - OEMs — warranty issues; information on own equipment performance and installation/service practices
  - Customers — better assurance equipment operates as OEM designed… and they paid for

- **Verification pressures: increasing calls by energy efficiency advocates for costly third party installation/service verification**

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Other Benefits

- **Workforce development**
  - Electronics more attractive and understood by younger generation
  - "Sexier" than traditional screwdriver and wrench vision of our trade
  - Fewer systems to learn and understand

- **OEM focus**
  - Pool resources (save time and money) to garner universal results
  - Savings can be used on other company projects

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Next Steps …
the Industry Needs to Develop

- **Common set of error codes and terminology that detail fault and error conditions**

- **Universal communication access configuration (ports or wireless)**

- **Standardized communication protocols (including input/output signals) for diagnostics**

- **Diagnostic tools/apps (e.g., code readers) that support functionality and output (report) basic fault information**

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Challenges

- **Application challenges**
  - Integrating variable distributed generation
    - Solar
    - Wind
  - Integrating storage at multiple layers
  - Integrating electric vehicles (EV)
  - Managing end-use loads
    - Residential
    - Commercial
    - Industrial
  - Enabling energy coordination and trading between buildings and trading between buildings and grid
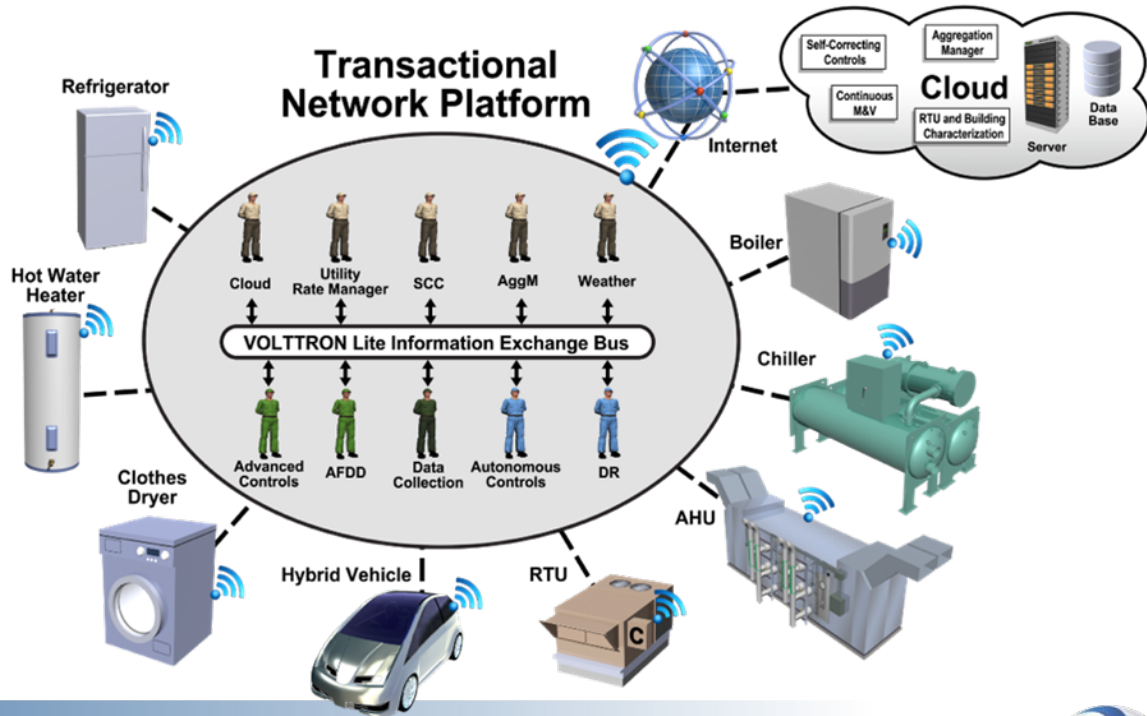- **Technology challenges**
  - Rapid deployment of networked (grid, buildings, etc.) sensors and controllers
  - Scalable control and diagnostics
  - Secure and reliable communication

Transactional Network Controls

- Buildings need to be smarter to participate in transactions within the building, with other buildings, and with grid entities.

- Sensors and controls at the whole building level and at the component level are fundamental to optimize DER and the grid.

- The transactional network enables energy-saving retrofit solutions.

AND

The networked systems transact with all grid-connected devices (e.g., EV, storage) and with the grid to help mitigate DER-related disturbances.

Transactional Network Platform

Refrigerator

Hot Water Heater

Clothes Dryer

Cloud · Utility Rate Manager · SCC · AggM · Weather

VOLTTRON Lite Information Exchange Bus

Advanced Controls · AFDD · Data Collection · Autonomous Controls · DR

Hybrid Vehicle

RTU

Internet

Self-Correcting Controls · Aggregation Manager · Continuous M&V · RTU and Building Characterization · Cloud · Data Base · Server

Boiler

Chiller

AHU

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PNNL Transactional Network Applications

- **Embedded advanced RTU controls**
  - Improve operational efficiency of RTUs through advanced RTU controls, leading to energy and carbon emission reductions between 30% and 50%.

- **Demand response agent**
  - Make RTUs grid responsive, leading to a more reliable electric power grid and mitigate variable distributed renewable generation.

- **Automated fault detection and diagnostics**
  - Detect economizer and ventilation failures as they occur and notify building operator to correct them
  - Refrigerant-side performance degradation (or improvement)
  - Energy and cost impacts of the degradation (or improvement)
  - Operation schedule changes
  - Selected operation faults, such as compressor short cycling, 24/7 operation, system never on and inadequate ventilation
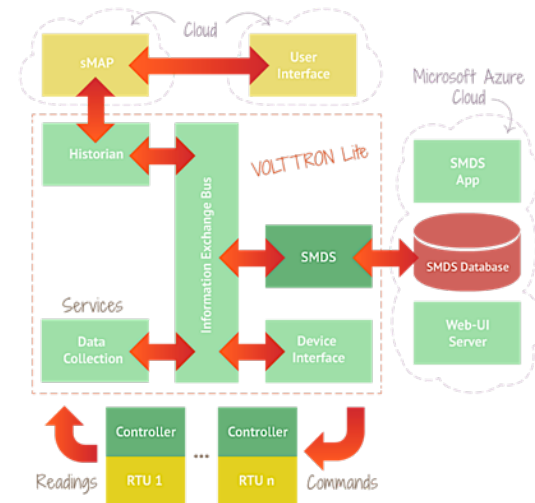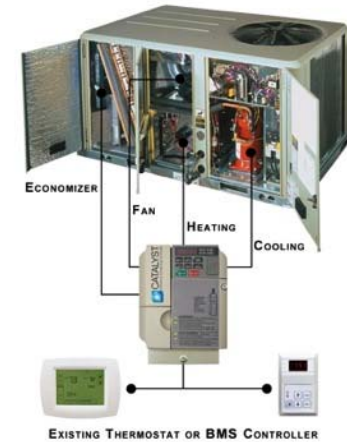
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Controls

Mission-Critical
Protection

Insight and
Visibility

Industry Best
Energy Efficiency

Simple and Low-Cost
Deployment

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Monitoring — Management

- **The more information you have, the better decisions you can make**

BUT…

- **What to do with it?**
- **Is the data good?**
- **How do I present the information?**
- **What is my core function?**

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Performance and Protection

Engineered solution

- Control routines
- Sensors
- Real-time data
- Troubleshooting

Customer refinement

- Fuel — miles to empty
- Miles per gallon — efficiency
- Actions
  - Time for service
  - Check engine

Connectivity/Security

Where to put data (Cloud, Fog, Device)

- Only 20% of the devices plugged in today are connected to the Internet
- 8.5 billion devices are connected to the Internet today
- Machine 2 Machine (M2M) technology will continue to grow

Protection

- Hackers will continue to attack
  - IT, building systems and remote access vulnerabilities
  - Viruses
- **EMP — magnetic pulses**

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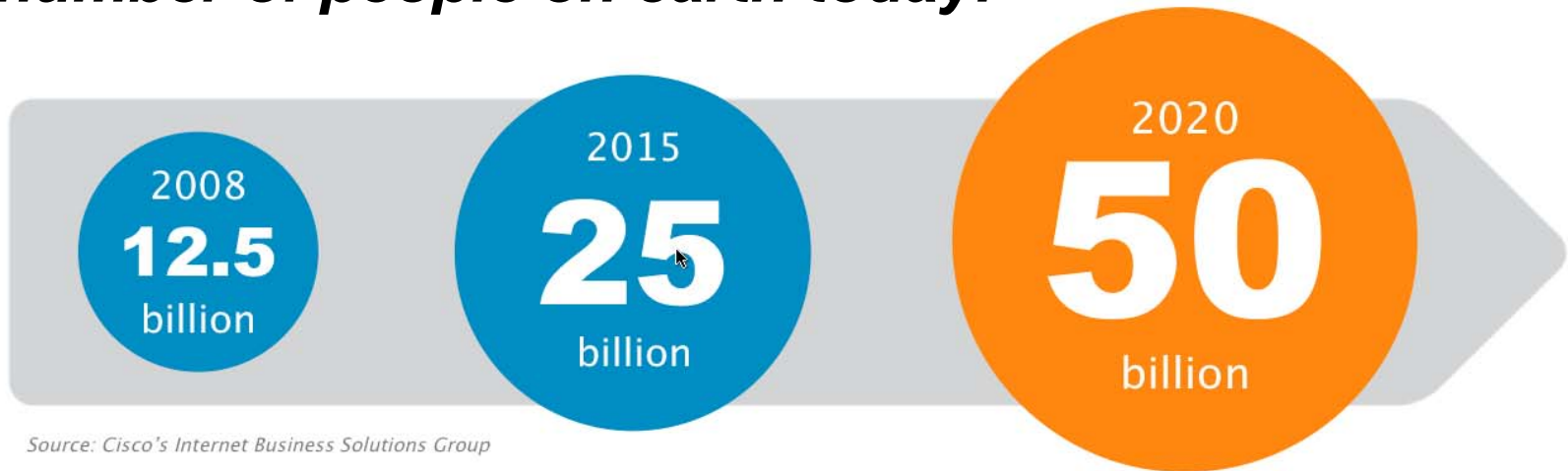*Emerson Climate Technologies*

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86% of U.S. CEOs Believe Technology Will Transform Their Businesses

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Why Is Data Important?

- **In a global economy, data becomes the most valuable currency to drive business transformation and product strategies.**

- ***By 2020,* the number of things connected to the Internet will be approximately *seven times greater than the number of people on earth today!***
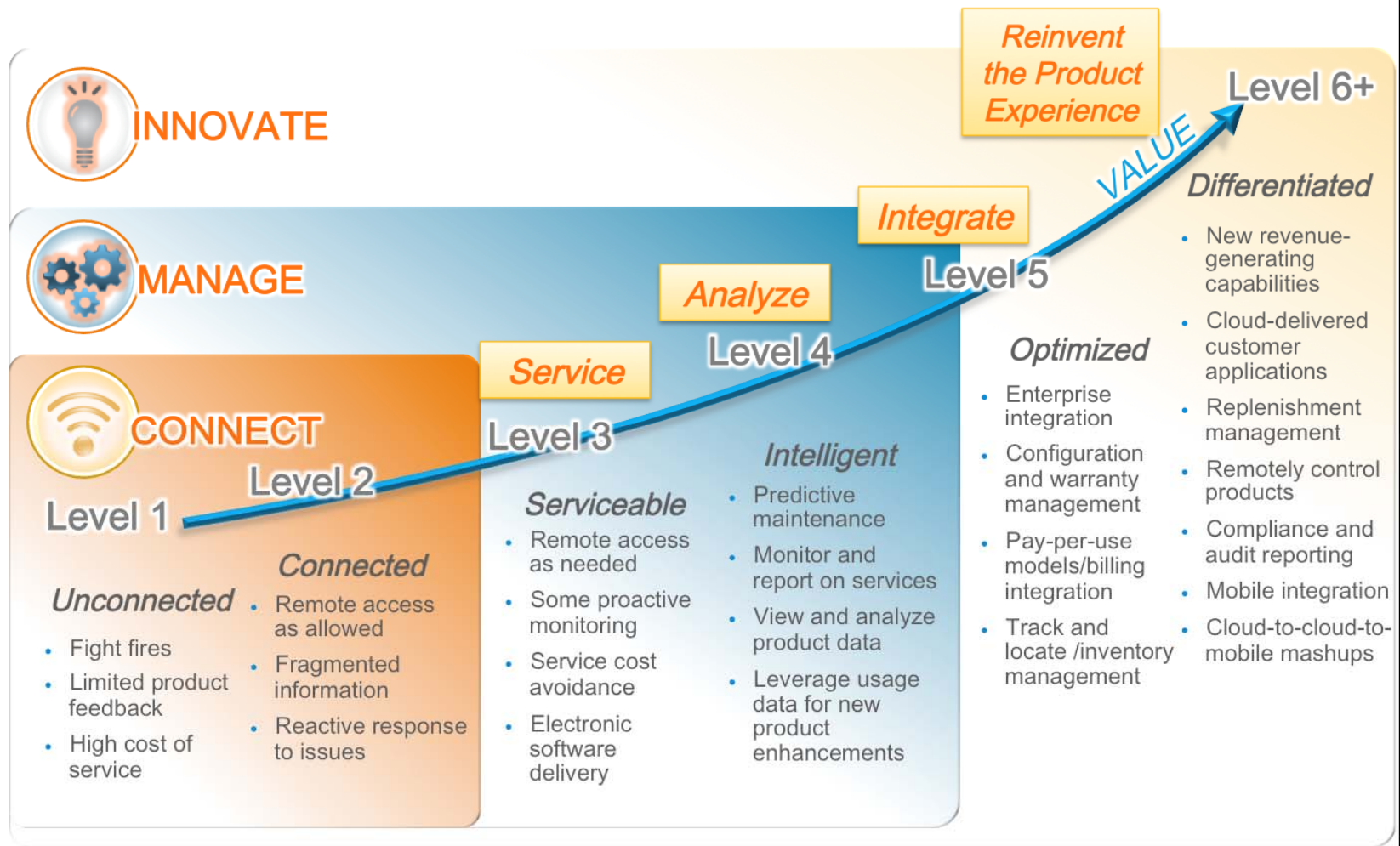
2008
12.5 billion

2015
25 billion

2020
50 billion

Source: Cisco's Internet Business Solutions Group

IoT

- **IoT will unlock new efficiencies and revenue opportunities, so you can reinvent your operations, business processes and services.**
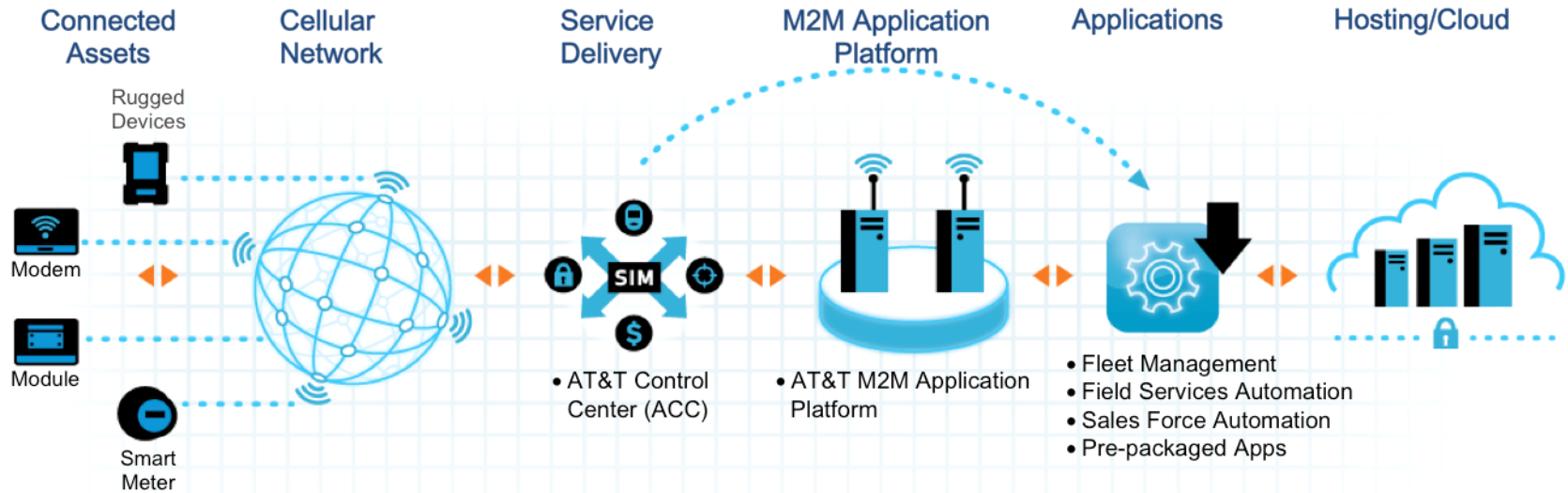

Increase revenue | Streamline operations | Reduce costs | Save time | Increase visibility

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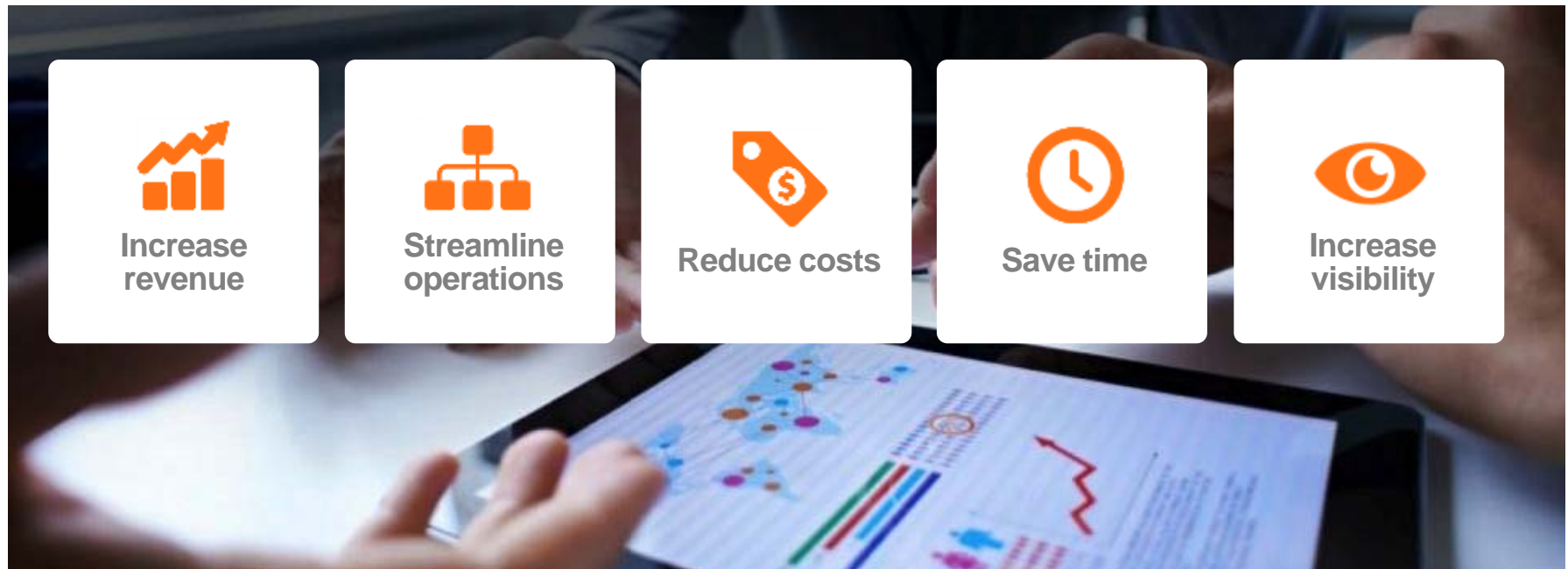
Connected Product Value Curve and Maturity Levels
Setting the strategy for next-generation business models

INNOVATE

MANAGE

CONNECT

Reinvent the Product Experience

Integrate

Analyze

Service

VALUE

Level 6+

Level 5

Level 4

Level 3

Level 2

Level 1

Unconnected
- Fight fires
- Limited product feedback
- High cost of service

Connected
- Remote access as allowed
- Fragmented information
- Reactive response to issues

Serviceable
- Remote access as needed
- Some proactive monitoring
- Service cost avoidance
- Electronic software delivery

Intelligent
- Predictive maintenance
- Monitor and report on services
- View and analyze product data
- Leverage usage data for new product enhancements

Optimized
- Enterprise integration
- Configuration and warranty management
- Pay-per-use models/billing integration
- Track and locate /inventory management

Differentiated
- New revenue-generating capabilities
- Cloud-delivered customer applications
- Replenishment management
- Remotely control products
- Compliance and audit reporting
- Mobile integration
- Cloud-to-cloud-to-mobile mashups

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IoT Solution Elements

Increase productivity through deployment of fully integrated mobile solutions

Connected Assets	Cellular Network	Service Delivery	M2M Application Platform	Applications	Hosting/Cloud

Rugged Devices

Modem

Module

Smart Meter

SIM

- AT&T Control Center (ACC)

- AT&T M2M Application Platform

- Fleet Management
- Field Services Automation
- Sales Force Automation
- Pre-packaged Apps

Provide professional services to design, integrate, deploy and manage across all areas of the solution.

Connected Assets
- Certified Modules
- Embedded Computing
- Sensors
- Modems
- Certified Devices

Cellular Network
- Over 16 Million M2M Connections
- Coverage in >200 Countries
- Global SIM

Service Delivery
- Billing
- Provisioning
- Diagnostics
- Business Rules

M2M Application Platform
- M2M Application Services
- Rules Engine, Data Model
- Agents, Device Protocol Adapters
- Connected Product Management Applications

Applications
- Vertical Applications
- Custom Applications
- Enterprise Application Integration
- Integration Framework

Hosting/Cloud
- Big Data/Analytics
- Scalable
- Secure

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IoT Transforming Products

Global heavy equipment monitoring solution

- Enables warranty services by collecting engine diagnostics and location of heavy equipment by using cellular, satellite and GPS services in 70+ countries

- Three distinct users of machine data
  - Service/repair
  - Owner/operator
  - Equipment manufacturer

Service/Repair

Owner/Operator

Equipment Manufacturer

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IoT Transforming Products (continued)

- **Service/Repair**
  - Information for parts and service
  - Service contracts
  - Warranty management
  - Rental tracking
- **Owner/Operator**
  - Business applications
  - Machine alerts
  - Security and curfew
  - Fleet coordination
- **Equipment Manufacturer**
  - Product cost reduction
  - Design optimization
  - Diagnostics
  - Machine performance
  - Failure analysis

Service/Repair

Owner/Operator

Equipment Manufacturer

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1. Wikipedia

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Our Digital Platform Now Watches Over 2M Fixtures and Processes 50M+ Alarms

IOT

Connecting Machines To Enterprise Management Systems

Data Management Services

Administrative Software Services

Call Center & Remote Oversight Services

Performance Management Services

Connecting Machines To Other Machines At Store Level
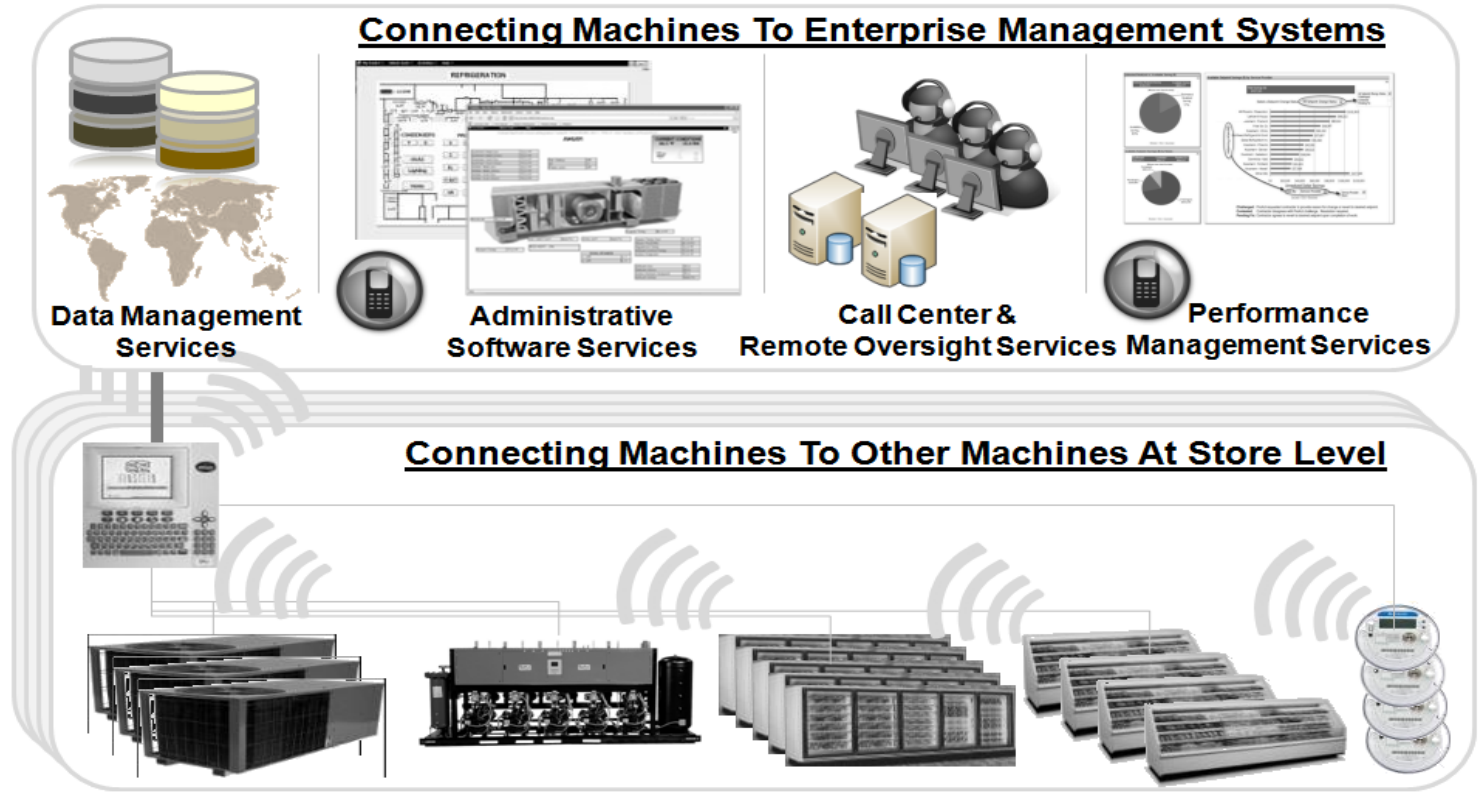
Cumulative Savings of More Than $100M Delivered to Customers Through Remote Services Over the Last 10 Years

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Using Data Across Enterprise to Identify Opportunities and Improve Performance

Enterprise-Level Monitoring

Using Store-Level Data Across Enterprise to Improve Total Cost of Ownership

Critical Rack Alarms

Norm Description
- Oil Failure
- Liquid Level
- Phase Fail
- Suction Pressure
- Compressor Fail
- Rack Failure
- Inverter Fail
- Pump Fail
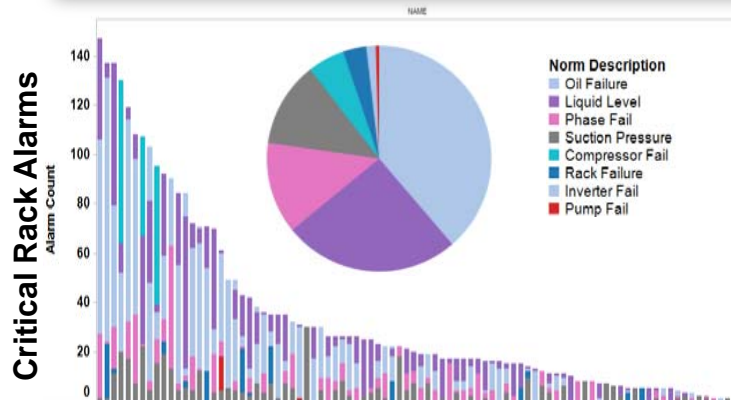
Maintenance and energy perspective:

- Identify top issues by occurrence and site location

- Establish "best of class" benchmark and identify worst performing stores

- Focus improvement by prioritizing equipment replacements and maintenance efforts

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What Type of Data Is Available?

Sensor Data

- Comp status on/off
- Oil pressure
- Discharge temp.
- Motor temp.
- Ambient temp.
- Comp. current
- Comp. power voltage
- Control circuit voltage
- Demand signal
- Contactor status
- Unloader status
- Digital modulation status
- Low/high pressure cut-out
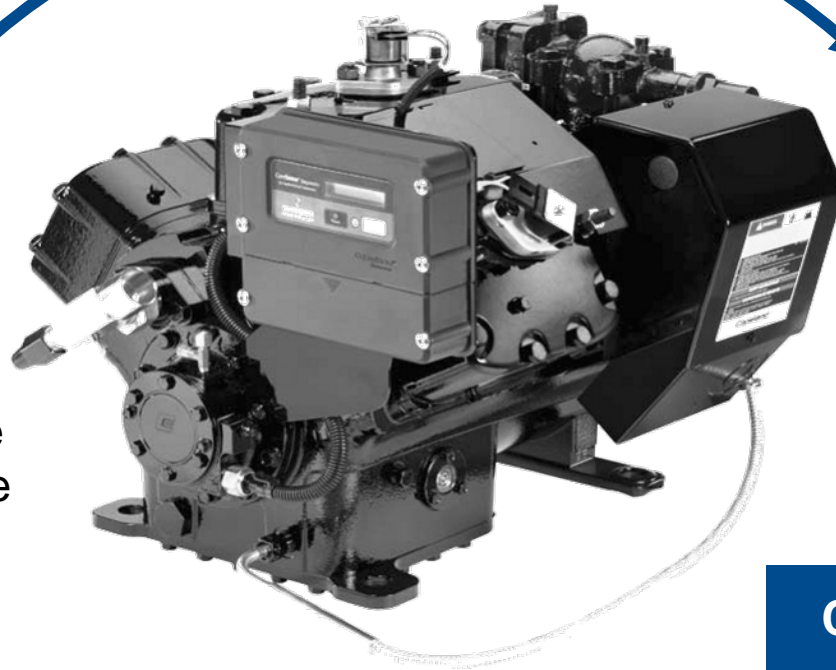
Insights

- Asset information
- Compressor proofing
- Power consumption
- Run and fault history
- Remote diagnostics
- System operation

Customer Value

- Applied cost savings
- Maintenance savings
- Energy efficiency

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FDD Data Coupled With Connectivity Enables Action to Prevent Failures

Early Notification of Growing Compressor Problems

Current Compressor Cycle Count

Five Days of High Cycling Equivalent to 100 Days of Normal Operation

Lifetime Cumulative Compressor Cycle Count
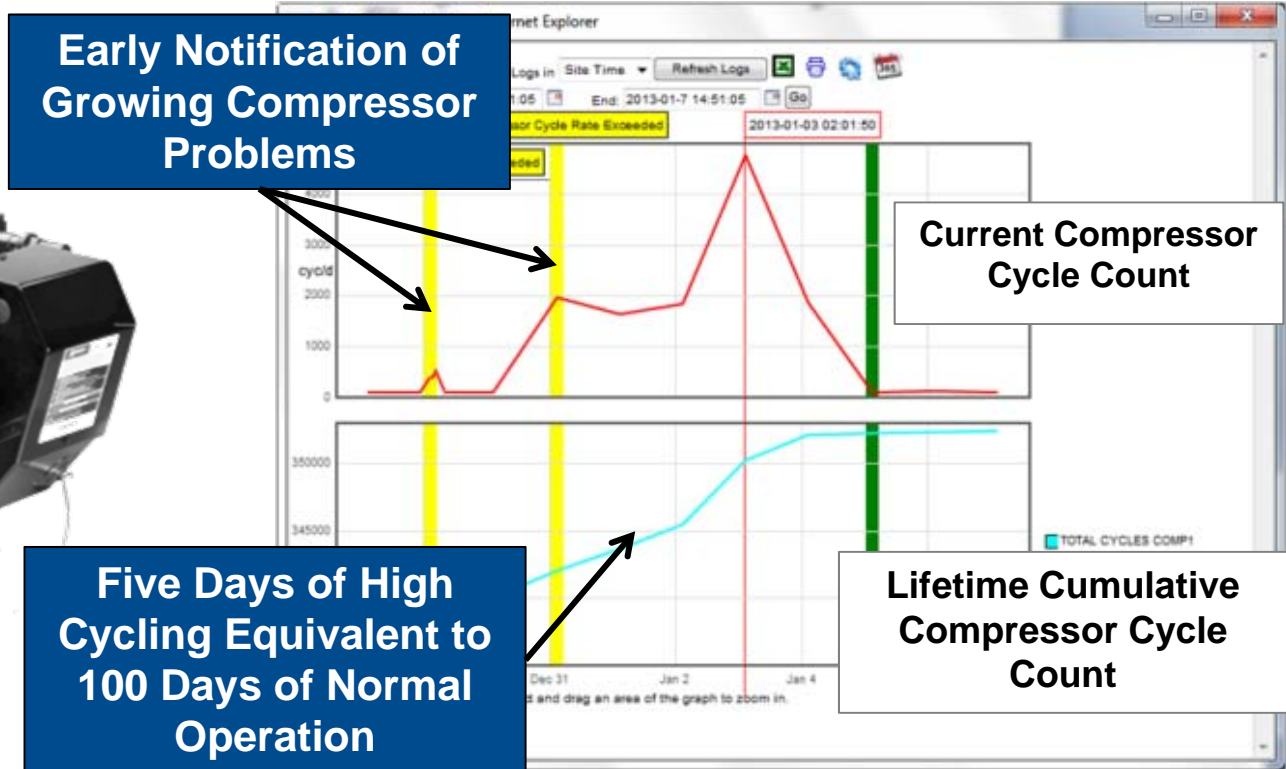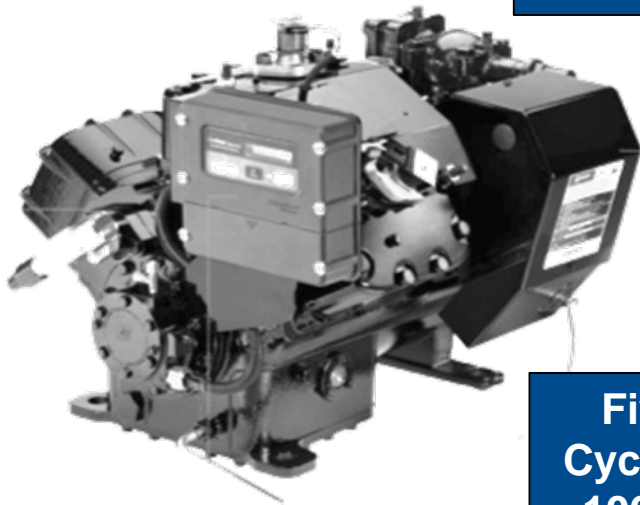
Typical Store Averaged 1–3 Compressor Replacements per Year Due to High Cycling ~ Savings up to $10K/Year/Store

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Systems Will Continue to Get Smarter and Have Greater Connectivity …

… Allowing Customers to Improve Total Cost of Ownership (Applied Costs/Operating Costs/Maintenance Costs)

Thank You!

Questions?

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