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February 2017

IoT Explained

"The Internet of Things (IoT) describes the revolution already under way that is seeing a growing number of internet enabled devices that can network and communicate with each other and with other web-enabled gadgets. IoT refers to a state where Things (e.g. objects, environments, vehicles and clothing) will have more and more information associated with them and may have the ability to sense, communicate, network and produce new information, becoming an integral part of the Internet."

IoT is comprised of three general domains; **Edge**, **IoT Platform**, and the **Enterprise**.

- The **Edge** is the front-line of IoT where sensor data is captured and transmitted to an IoT Platform. This is IoT's least mature segment and is comprised of volatile set of competing technologies and standards.
- The **IoT Platform** is a cloud-based IoT service (e.g. Microsoft's Azure™ IoT Platform) enabling Data Analytics, Machine Learning, Web Services, Device Management and Remote Monitoring.
- The **Enterprise** consists of existing corporate networks and legacy applications integrated with the IoT platform, including Enterprise Resource Planning (ERP) and Customer Resource Management (CRM) platforms.

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IoT Value Propositions Realized

Although there are several value propositions for organizations to adopt IoT efforts, below are some of the primary benefits IoT can provide:

- Cost-cutting or operational savings. There are many well-documented ways to reduce operational costs with IoT implementations. As an example, the food distribution industry can utilize sensors to monitor food shipments during delivery to identify potential spoilage that occurs due to failed refrigerants or delays in delivery. By avoiding spoilage, food distribution companies can save some of the roughly 30% of their food supply that is lost during transit.
- Quality of Experience (QoE). There are opportunities to improve overall customer satisfaction, which can significantly improve customer retention. One example is with home appliances, where manufacturers can monitor appliances for degradation in performance and proactively deploy service technicians to fix appliances before they break.
- Additional Revenue Generation. Companies can offer value-added services through IoT offerings. For instance, a company can monitor battery power levels of remote construction equipment and sell that as part of a labor service to manage battery replacement.

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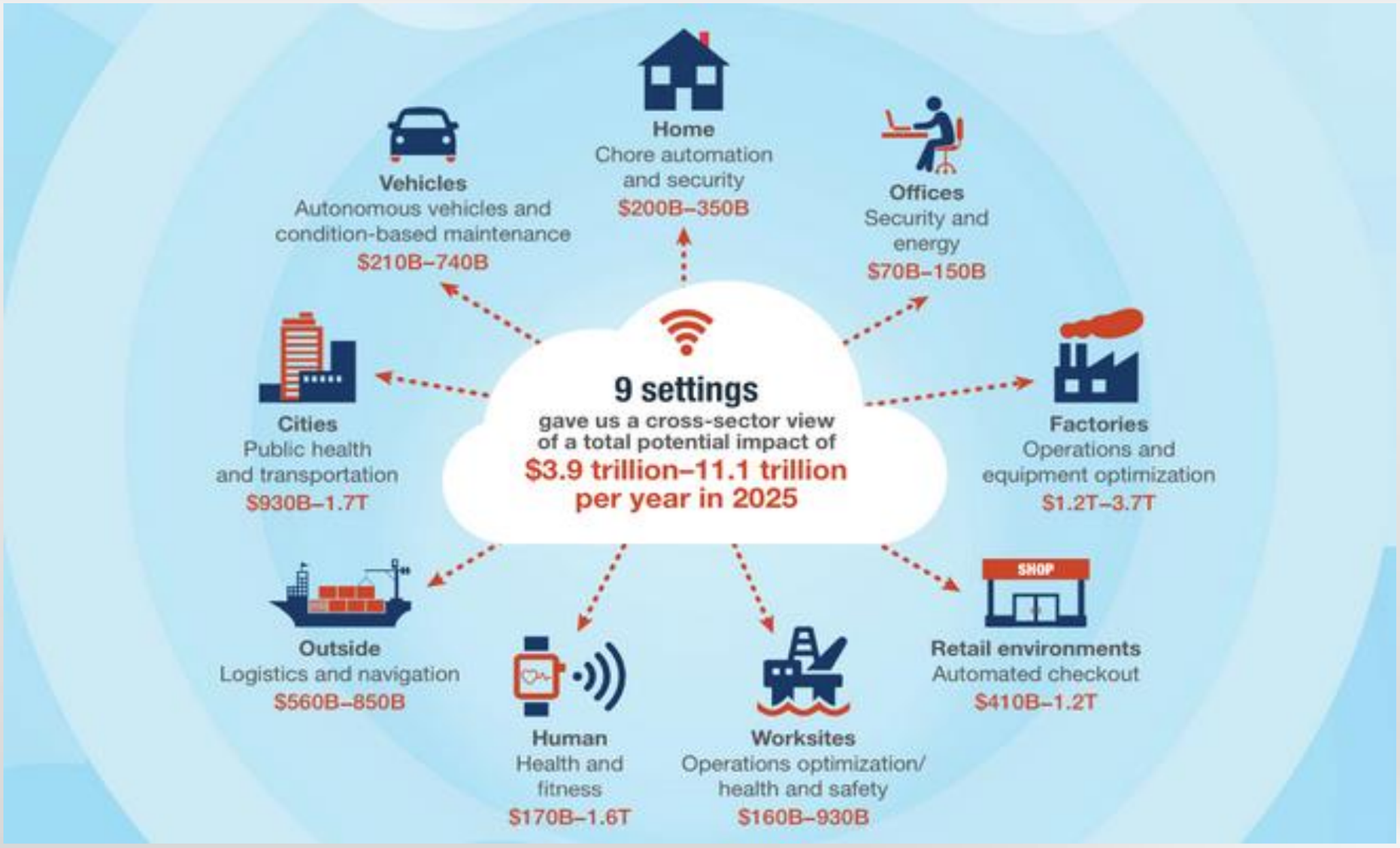
IoT Market Segments & Capitalization

The Internet of Things (IoT) market is expected to expand to $3.9-$11.1 trillion per year by 2025 according to composite projections from leading research organizations including Gartner, Forrester, and Microsoft.



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TerraTrace™

TerraTrace™ is a turn-key, ***IoT Edge Platform,*** providing a hardened and secure network extending from the sensor to the IoT Platform, solving some of the biggest issues facing IoT; Security, Interoperability, Mid-Range Wireless Transmission and Power Management.

OpenWare™

OpenWare™ is a ***family of Edge Hardware components*** core to the TerraTrace™ architecture. Key benefits include significant improvements in IoT Edge equipment performance, increased device intelligence, standardization and enhanced networking capabilities.

IoT-as-a-Service℠

IoT-as-a-Service℠ is a monthly service fee model to simplify the IoT decision making process by providing ***a completely open and customizable IoT offering*** to future-proof IoT infrastructure investments, eliminate up-front hardware costs and mitigate many of the risks when designing IoT solutions.

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Microsoft Azure

Certified

Archetype Delivers Azure-Based IoT Solutions Featuring OpenWare™, the only complete IoT Edge hardware series certified by Microsoft.

With TerraTrace™ and OpenWare™ technologies, Archetype can turn your two - year development cycle into a two month process while dramatically reducing up-front costs.

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Corporate Overview

- 2002 - Archetype Inc., was founded to build mission-critical, embedded hardware and Internet enabled systems.
- 2005 - Archetype worked closely with Siemens AG to develop “M2M One”, Siemen’s premier M2M platform and precursor to the Internet of Things.
- 2008 - Archetype was chosen by Siemens AG, as their “Best-of-Breed” M2M provider to deliver TerraTrace™ based M2M solutions for Siemens’ Tier 1 customers.
- 2010 - Archetype begins leveraging TerraTrace™ to focus on IoT-based initiatives as the industry’s only “one-stop-shop” IoT Edge Platform.
- 2016 – OpenWare™ becomes the only Microsoft Azure™ IoT Certified complete IoT Edge hardware series commercially available.

Patent approval of 150 claims predating the competition in wearables, covering the application of more than one sensor type on the body to capture biometric data and the wireless transmission to the cloud.

Hundreds of additional claims related to OpenWare™ hardware designs, the OpenWare™ wireless protocol and network infrastructure pending.

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TerraTrace™ IoT Edge Platform

TerraTrace™ is an intelligent wireless IoT Edge Platform, providing standardization and security from the sensor to the IoT Platform

- The TerraTrace™ exclusive OpenWare™ 4-phase commit, mid-range (1,000 feet to ½ mile line-of-sight) wireless protocol, guarantees data delivery and goes well beyond the stability of other platforms; making it ideal for mission critical, healthcare and industrial applications.
- TerraTrace™ includes an extensive line of power efficient OpenWare™ Sensor Devices, fully customizable to meet specific business requirements and supports the integration of over 10,000 sensor types.
- Long-range backhauling is provided using cellular (GSM, CDMA, etc.), satellite (Orbcomm, Iridium, GlobalStar), or the Internet through a Wi-Fi or land-line connection.
- The ability to control Transmission Frequency and Exception-Based reporting models, coupled with the TerraTrace™ Online Portal, enables companies to control and monitor edge sensor data in real-time.

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OpenWare™ Explained

- The OpenWare™ Wireless Protocol implements a **4-phase commit strategy** ensuring data is delivered accurately down to the last byte.

Phase 1	• OpenWare™ Sensor Device collects data. • Analyzes data and processes if needed (intelligent processing). • Transmits processed data to an OpenWare™ Router/Gateway.
Phase 2	• Router/Gateway device receives data. • Sends "checksum" back to Sensor Device.
Phase 3	• Sensor Device reads "checksum" to verify data sent correctly. • Device transmits back a "success" or… • In case of "failure", rolls back and restarts transaction.
Phase 4	• Router/Gateway receives status, and if "successful" transmits data to IoT platform. • If "failure", rolls back and restarts transaction.

- **OpenWare™ maintains data integrity from the sensor to the IoT Platform**. If a Sensor Device is in range of multiple OpenWare™ Edge Routers/Gateways, data is only received by one Router/Gateway, ensuring no data duplication while eliminating unnecessary network traffic.

- **The OpenWare™ protocol was developed 10 years ago** and has been in production use internationally for over 6 years, making it a proven wireless protocol for mission critical applications.

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TerraTrace™ Security

- TerraTrace™ **sensor data cannot be altered** from the point of capture with an OpenWare™ Sensor Device all the way through to the IoT Platform, ensuring no tampering or malicious data being inserted into the IoT system.
- The OpenWare™ mesh network, closed-hardware transmission design, **prevents new software from being injected into any devices along the entire transmission channel** eliminating the threat of Viruses, Malware, and all current forms of Ransomware.
- **Data is fully encrypted** from the OpenWare™ Sensor Devices to the IoT Platform and is never decrypted until successfully arriving in a secure web deployment. This translates to having fully secured data channels all the way through the communication path, ensuring the best overall data security for IoT systems.
- TerraTrace™ IoT implementations can be designed so there is **no single point of failure** along the entire transmission path, providing the highest level of redundancy and recoverability for sensor data.

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OpenWare™ Interoperability

One of the biggest design challenges with today's IoT Edge networks is the uncertainty caused by competing standards, technologies and platforms. This lack of interoperability and adopted standards are major concerns when designing IoT networks and deciding which technologies and platforms to use.

- The TerraTrace™ IoT-as-a-Service℠ delivery model enables customers **integrate with any existing wireless protocols** including; OpenWare™, Bluetooth Smart (LE), ZigBee and Wi-Fi fully integrated into any OpenWare™ Sensor Devices, Edge Routers or Edge Gateways.
- **OpenWare™ Gateways are fully integrated with Microsoft's Azure™ IoT Platform**, and supports all forms of data backhauling to Microsoft's Azure™ IoT Platform including cellular, satellite, and landline via the Internet.
- **Firmware upgrades Over-the-Air (OTA) are fully supported** to all OpenWare™ Hardware, further ensuring future interoperability with new sensor arrays and business needs. OTA calibration of sensors, including accelerometers, heat, etc., is fully integrated with the TerraTrace™ IoT Portal.

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OpenWare™ Wireless Protocol

Comparison - Standard Antenna

Module Type	Range w/standard Antenna	Power Consumption Avg. at 60 Sec Transmit Time	Frequency	Data Rate	Direct to Azure™
OpenWare™	**1,000 – 2,500 Ft**	**3.2µA @3.3v**	**300 to 930mHz**	**250kbps**	**Yes**
ZigBee / XBee	300 Ft	40µA @ 3.3v	2.4GHz	250kbps	No
Bluetooth Smart (LE)	250 Ft	18µA @ 3.3v	2.4GHz	270kbps	No
ANT	150 Ft	55µA @ 3.3v	2.4GHz	20kbps	No
Wi-Fi 802.11ah	450 Ft*	N/A	902-928 MHz	150 kbps*	No

• Projected numbers as test modules are not readily available yet

Please see Appendix for testing methodology and detailed results.

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IoT As A Service℠ Explained

IoT-as-a-Service℠ is a monthly service model to simplify IoT designs and implementations by providing a standardized and open edge platform, that is customizable to meet the unique needs of each business case. All it takes is three easy steps:

1. Define your IoT business needs and identify which type of sensor data is needed to fulfill the business case requirements.
2. Select the desired wireless protocol for the IoT system's edge communications (e.g. OpenWare™, Bluetooth LE, ZigBee and Wi-Fi); and select the backhauling strategy for transmitting data to the Azure™ IoT Platform (e.g. cellular, satellite, and landline via the Internet).
3. Select which TerraTrace™ services are needed, whether leveraging IoT Platform Services such as Machine Learning, integrating into an existing ERP/CRM system for remote monitoring of equipment, providing a real-time Online Portal to track customer experience, or other IoT use case.

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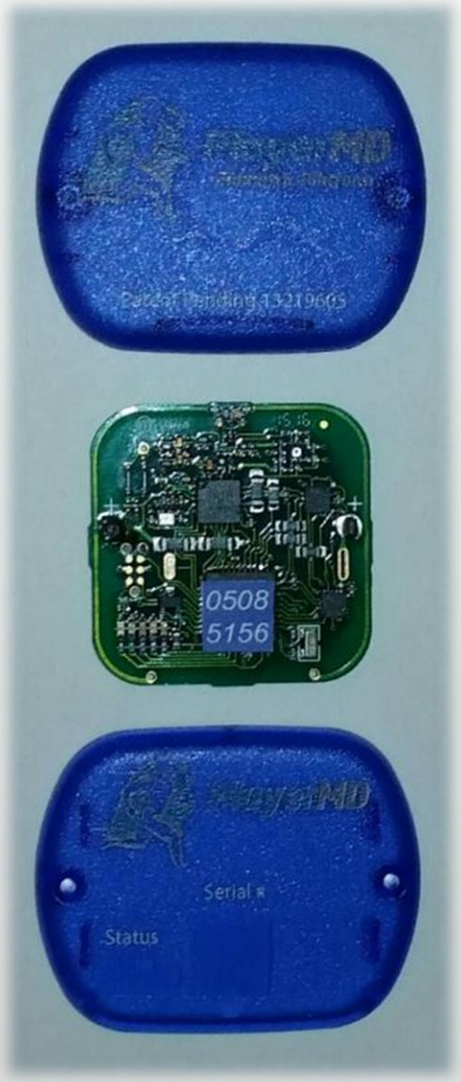
OpenWare™ Sensor Device

Micronized sensor deployment packages hardened for extreme environments

- A minimum of seven open ports are available to integrate sensors with up to a 3.5 volt output, wireless API included.
- Dimensions (l x w x h) - 4.5cm x 3.5cm x 3mm, weighs 15 grams with battery.
- Will survive up to 1,000 Gs of shock and temperatures from -40° to 180° Fahrenheit.
- Replaceable coin cell batteries allows 400 hours of continuous use and a rechargeable configuration allows 250 hours of constant use per charge.
- If set to 5 minute updates, the contained battery packs can power an OpenWare™ Sensor Device for 10+ years.
- Rechargeable configuration can be wired to existing power sources to allow long-term use and battery backup in the field.



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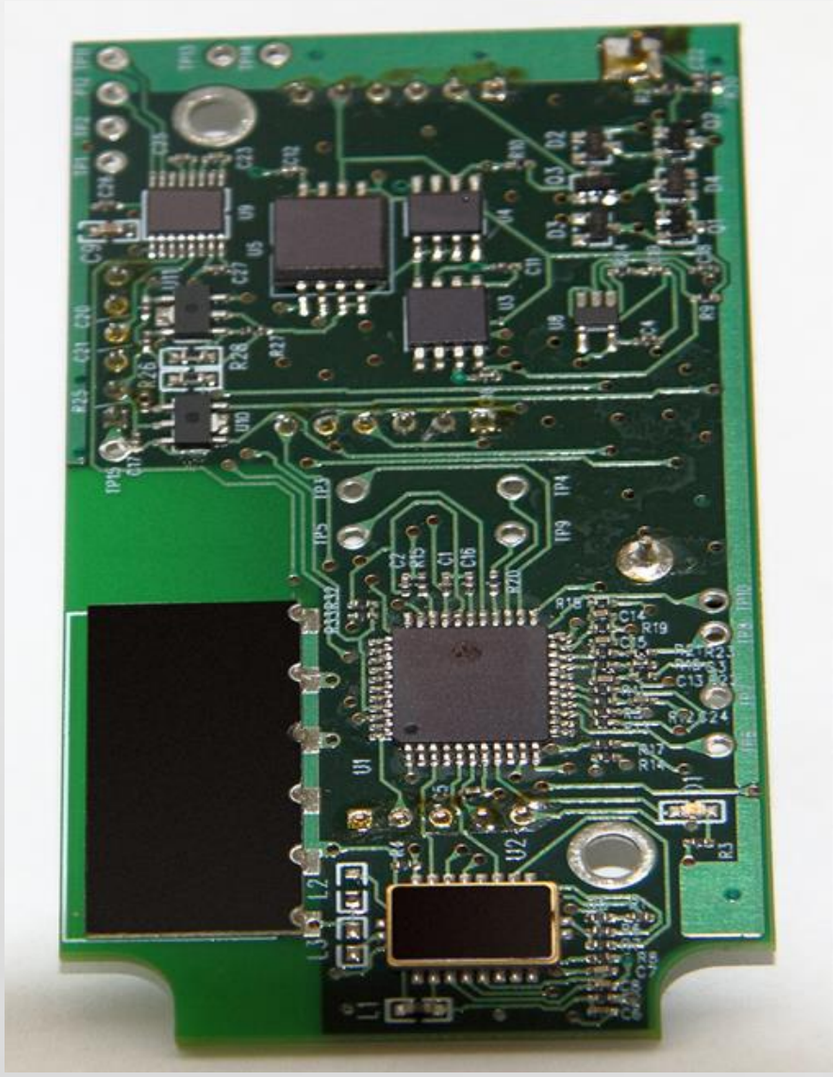
OpenWare™ Edge Router

- A wireless OpenWare™ Edge Router attached to a tablet, smart phone or laptop, collects sensor data for up to 128 simultaneous OpenWare™ Sensor Device transmissions, which means one OpenWare™ Edge Router can potentially support millions of OpenWare™ Sensor Devices.
- OpenWare™ Edge Routers can wirelessly relay data to an OpenWare™ Edge Gateway for transmission to Microsoft's Azure™ IoT Platform. This is the recommended layout for large-scale IoT implementations.
- OpenWare™ Edge Routers have a ½ mile range and can be extended to 20 miles if needed.
- Encrypted data is received from the Sensor Device and is passed to Microsoft's Azure™ Platform using the OpenWare™ 4-Phase Commit Wireless Protocol.
- The OpenWare™ Wireless Protocol will not interfere with devices using other protocols such as Wi-Fi, Bluetooth LE or ZigBee.



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OpenWare™ Edge Gateway

- The OpenWare™ Edge Gateway can concentrate data from OpenWare™ Edge Routers in a mesh or grid-style network configuration.
- OpenWare™ Edge Gateways have a ½ mile range and can be extended to 20 miles.
- OpenWare™ Edge Gateways support all standard communication protocols including HTTPS, AMQP and MQTT transmitted over Wi-Fi, cellular, satellite or landline Ethernet to the Internet.
- Data is encrypted from the OpenWare™ Sensor Device to Microsoft's Azure™ cloud platform using the OpenWare's™ 4-Phase Commit Wireless Protocol.
- OpenWare™ Wireless Protocol does not interfere with devices using other protocols such as Wi-Fi, Bluetooth LE and/or ZigBee.

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How TerraTrace™ Works

Edge

10,000+ types of sensors can be integrated into TerraTrace™.

OpenWare™ Sensor Device

Up to ½ mile line-of-site

OpenWare™ Edge Gateways & Routers capture up to 128 simultaneous transmissions from OpenWare™ Sensor Devices

OpenWare™
Edge Hardware Family

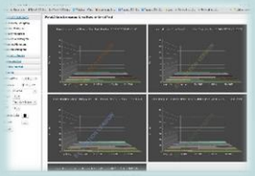
Data is encrypted from the sensor to the IoT Platform using the OpenWare™ proprietary wireless protocol with a 4-phase commit to ensure successful receipt of all data.

GSM & Wi-Fi Networks

IoT Platform

Microsoft Azure™ IoT Platform

Enterprise



Online Web Portal

Enterprise Systems

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APPENDIX

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Power Consumption Comparison

OpenWare™, Bluetooth LE, ZigBee and ANT

(Cyclic Sleep Scenario)

- The following compares the electrical current consumed by the radio portion of the OpenWare™, Bluetooth LE, ZigBee and ANT protocols
- Data for Bluetooth LE, ZigBee and ANT protocols was taken from a 2013 IEEE paper.
  - Title: "*Power Consumption Analysis of Bluetooth Low Energy, ZigBee and ANT Sensor Nodes in a Cyclic Sleep Scenario*"
  - Authors: Artem Dementyev, Steve Hodges, Stuart Taylor and Joshua Smith
- The data for the OpenWare™ protocol was measured and added to the IEEE data.
  - IEEE data was estimated from charts if not explicitly given in a table

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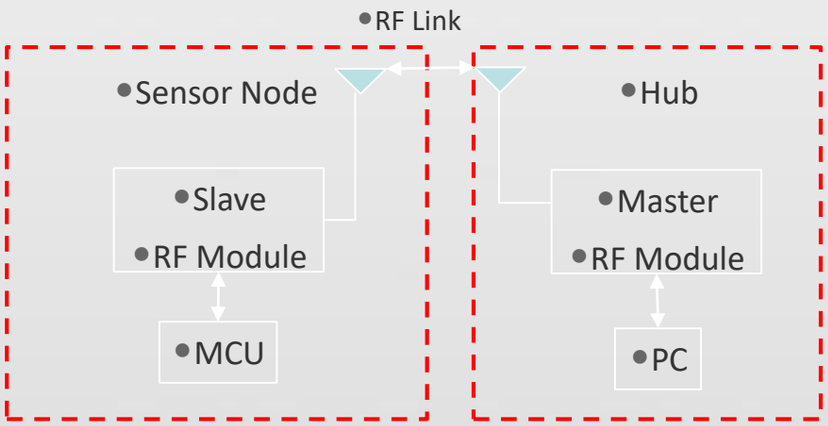
Testing Methodology

- Send one 8 byte data packet from sensor to hub
  - Transmit power: 0dBm
  - Distance between node and hub: 30cm
  - Wait for packet acknowledgement
  - No encryption
  - Power supply level: 3.3 V
  - Repeat every 5, 10, 30, 60 and 120 seconds
  - Optimize the master/node for fastest connection establishment
- Record average current of sensor node
  - Subtract any current contribution from the MCU

RF Module Setup

Module Chararacteristic	BLE	ZigBee	ANT	OpenWare™
RX Sensitivity	-87dBm	-102dBm	-85dBm	-105dBm
Tx Power	0dBm	0dBm	0dBm	0dBm
Freq. Hopping	Yes	No	No	No
Frequency	2.4 GHz	2.4 GHz	2.4 GHz	916 MHz
Advertising Period	100 ms	100 ms	10 ms	N/A
Period between RF Packets	100 ms	100 ms	250 ms	N/A



Experimental Block Diagram

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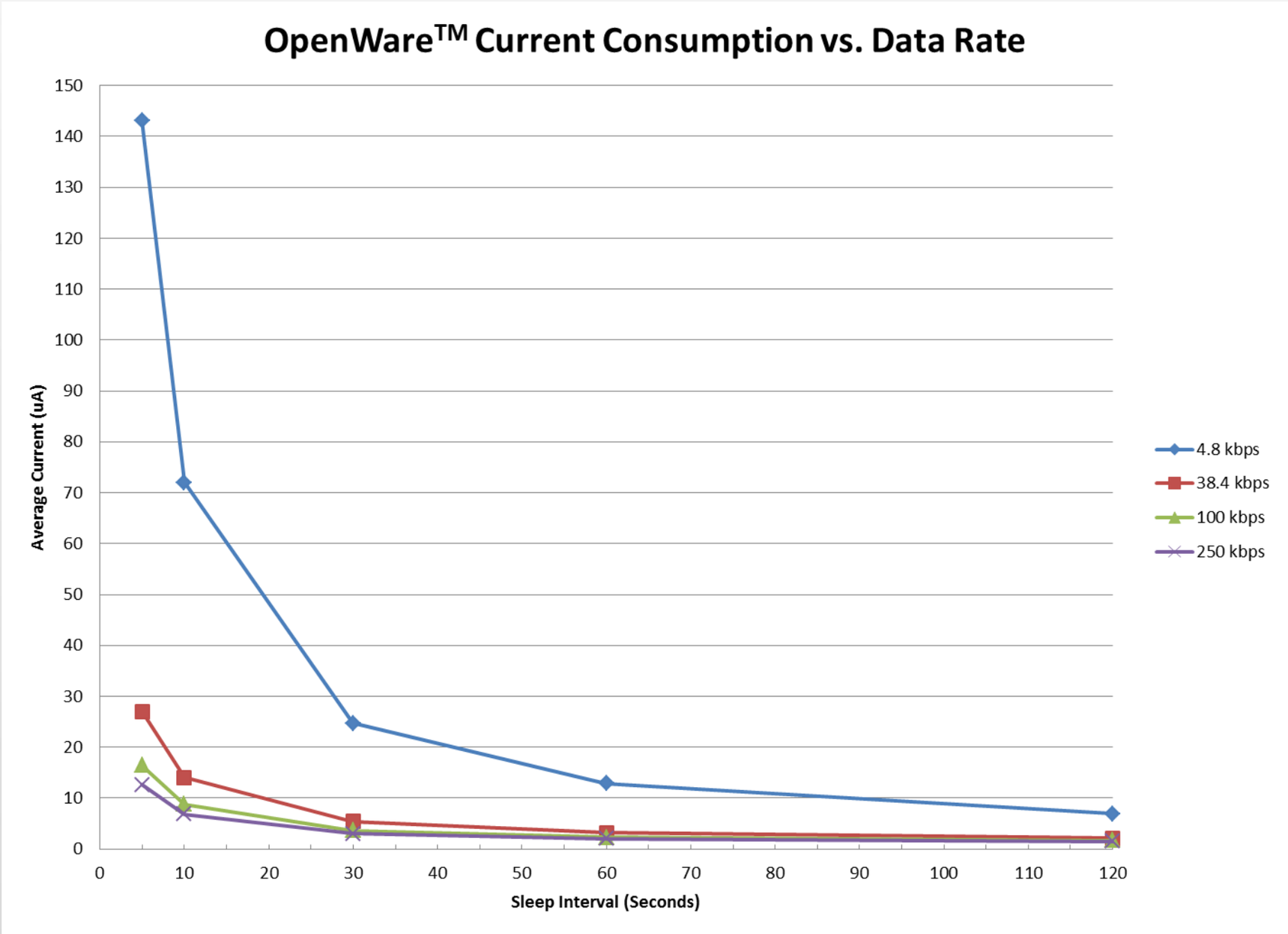
Results - Data Rate to Current



- Packet Size = 8 bytes

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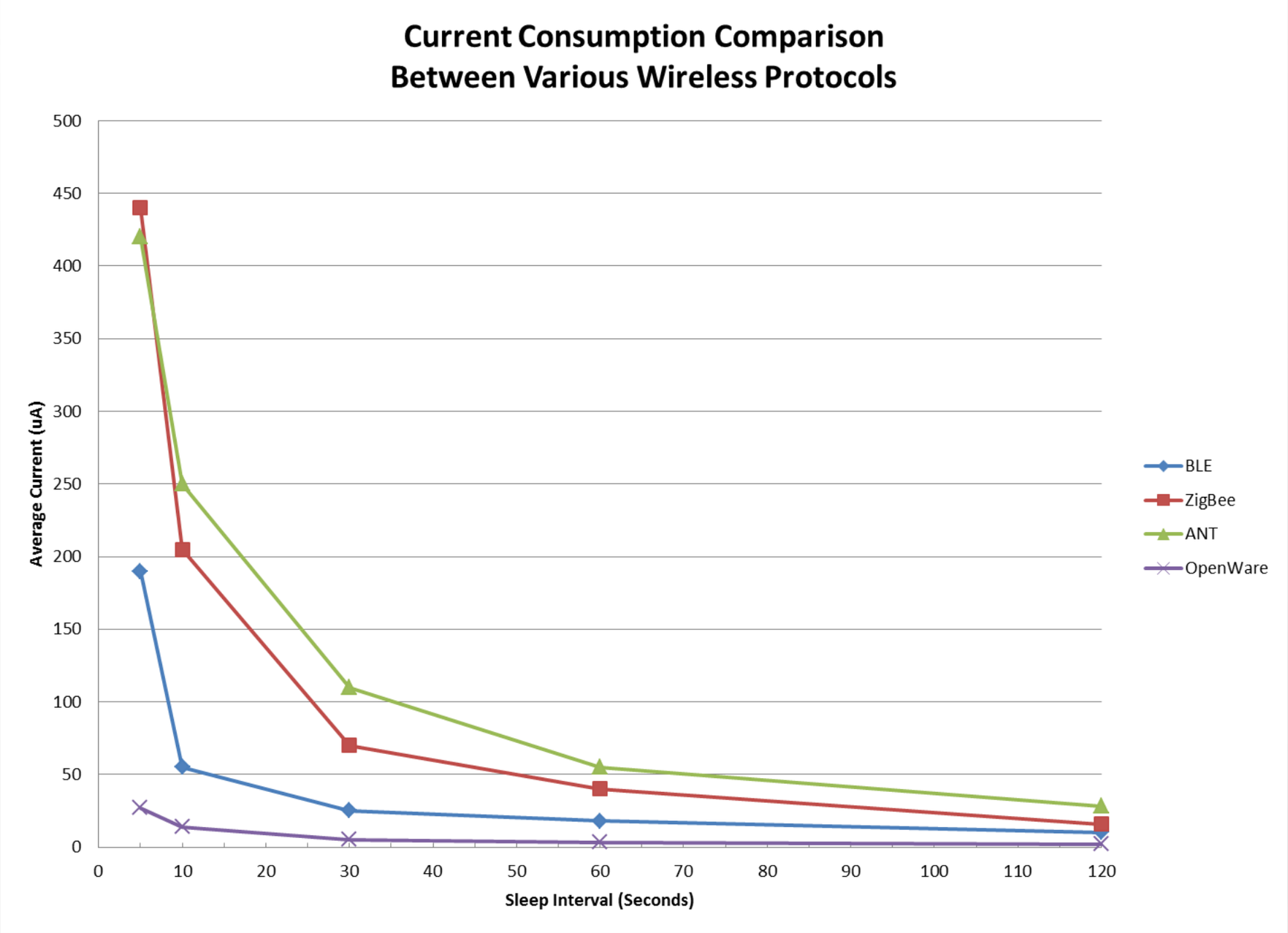
Results - Power Management



- Packet Size = 8 bytes

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Power Consumption Results

Conclusions:

- The OpenWare™ Wireless Protocol provides significantly lower average current requirements than the other protocols tested.
- Average current in the OpenWare™ Wireless Protocol can be reduced by increasing the data rate above the standard 38.4kbps.
- Increasing data rate decreases RF range.

Comments:

- The IEEE paper identifies the amount of time required to establish a connection between the node and hub as the dominant factor for current consumption.
- The OpenWare™ Wireless Protocol does not require an explicit link connection which allows for a fast TX / ACK sequence.
- The fast sequence keeps the radio in sleep mode most of the time and reduces current.

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