Learning Outcomes

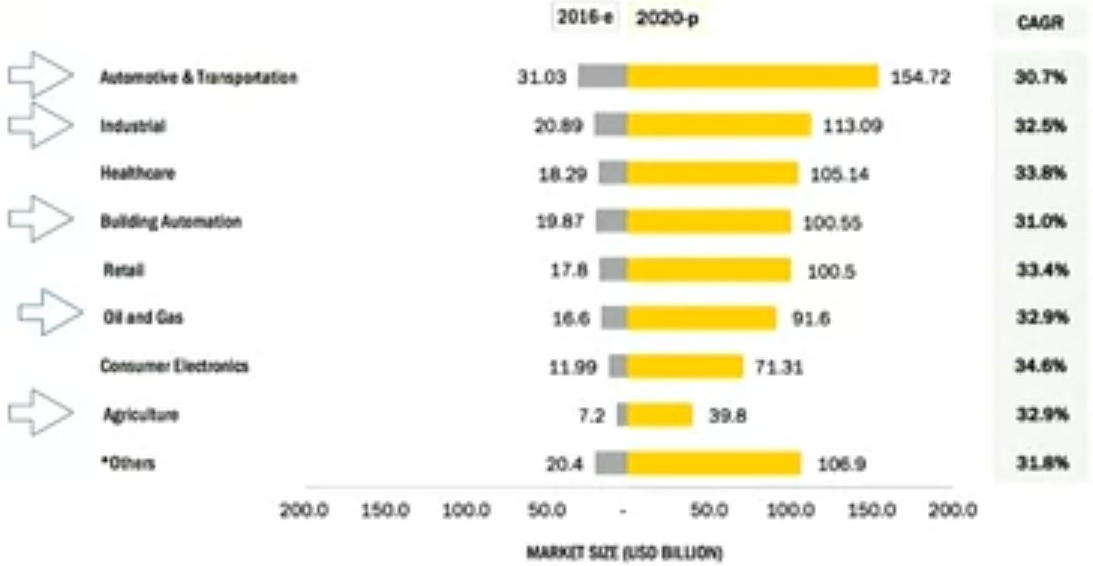
- Gain an understanding of the 5 largest IIoT market application areas
- Identify the key operating systems currently in use and those that have the potential to trend upwards

the five largest Industrial Internet of Things market application areas.

Material

- 5 Markets by Application:
  - 1 - Automotive and Transportation
  - 2 - Industrial / Manufacturing
  - 3 - Building Automation
  - 4 - Oil and Gas, Energy
  - 5 - Agriculture
- Operating Systems

FIGURE 9 AUTOMOTIVE & TRANSPORTATION APPLICATION TO DOMINATE THE IOT TECHNOLOGY MARKET DURING THE FORECAST PERIOD



Previously, we saw this slide from the market group research report.

5.3.3 BY APPLICATION

The IoT market has been broadly segmented on the basis of applications into consumer electronics, building automation, industrial, automotive & transportation, and healthcare.

Application	Description
Consumer Electronics	Consumer electronics segment is an area of interest for many players in the IoT market. The segment covers smart appliances and wearable devices.
Building Automation	Building automation segment is expected to be driven by a huge demand for the energy-efficient solutions, enhanced security, and enabled building systems. Connectivity technologies used in the segment include ZigBee, Z-wave, EnOcean, Wi-Fi, and Bluetooth.
Industrial	Industrial segment covers sensors, actuators, and software that enable connectivity between machines in an industrial environment. This area is of major interest to big industrial automation companies such as Honeywell, GE, and Siemens.
Automotive and Transportation	This segment covers the connected car and intelligent transportation market and is seeing a lot of activity in terms of investment in research and development.
Healthcare	The healthcare segment covers devices that allow on premise as well as remote monitoring or self-monitoring by patients themselves. These include pulse oximeter, blood pressure monitor, and heart rate monitor among others.
Agriculture	The agriculture segment covers wireless sensors used to measure important parameters such as soil temperature, soil humidity, temperature, among others.
Oil & gas	The oil & gas segment covers wireless sensors including pressure sensors, level sensors, temperature sensors, and flow sensors.
Retail	The retail segment includes the market for smart beacons in retail outlets. The platform solutions, software, and services market for retail is also covered.

Building automation segment is expected to be driven by

Automotive and Transportation (con't)

- "The automotive and transportation segment covers connected cars and intelligent transportation systems (ITS). ITS includes sensors, communication, and traffic control technologies. These technologies assist states, cities, and towns across the globe to meet the increasing demand for surface transportation systems. Vehicle detection and surveillance technologies are an integral part of ITS as they gather all or part of the data used in intelligent transportation systems and are being improved continuously to provide enhanced speed monitoring, traffic counting, presence detection, headway measurement, and vehicle classification."

"The Automotive and transportation segment covers

Automotive and Transportation (con't)

- "Connected cars are equipped with devices that enable Internet access inside a car and allow it to communicate with other cars on a road, infrastructure that includes traffic stop signals, satellites, cloud- based services, and road-side antennas among others are likely to witness greater adoption in the near future. The **market for connected cars is expected to grow exponentially** in the near future, which can be gauged from the fact that tech giants from Apple to Google as well as big automotive players such as Volkswagen, Nissan, and Mercedes have already launched their connected car prototypes in the market."
- "In 2014, AT&T introduced a connected car service in partnership with a number of automobile manufacturers including Audi, GM, and Volvo that offer high-speed 3G or 4G connections for a monthly subscription fee of just 10 USD."

Volvo that offer high-speed 3G or 4G connections

Automotive and Transportation (con't)

TABLE 45 IOT TECHNOLOGY MARKET FOR AUTOMOTIVE & TRANSPORTATION APPLICATION, BY OFFERING, 2013–2022 (USD BILLION)

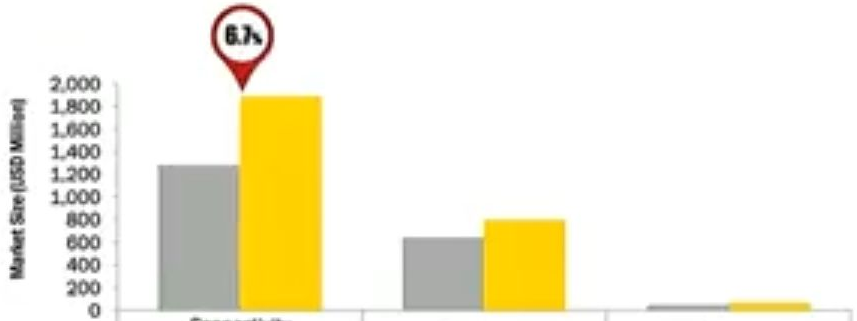
Offering	2013	2014	2015	2016-e	2018-p	2020-p	2022-p	CAGR (2016–2022)
Platform, Software solutions, and Services	12.50	16.74	23.23	29.05	48.00	85.30	151.96	31.8%
Hardware	1.45	1.62	1.79	1.98	2.26	2.50	2.76	5.7%
Total	13.95	18.36	25.02	31.03	50.26	87.80	154.72	30.7%

the estimate was almost 30 billion for

6:06

Automotive and Transportation (con't)

FIGURE 50 CONNECTIVITY TECHNOLOGY SEGMENT TO DOMINATE THE IOT TECHNOLOGY MARKET FOR AUTOMOTIVE AND TRANSPORTATION APPLICATION



	Connectivity Technology	Processors	Sensors
2016-e	1,282.6	644.4	49.4
2022-p	1,889.0	801.4	68.4
CAGR (2016-2022)	6.7%	3.7%	5.6%

This figure shows conductivity technology segment to

Automotive and Transportation (con't)

TABLE 47 IOT TECHNOLOGY MARKET FOR AUTOMOTIVE & TRANSPORTATION APPLICATION, BY PROCESSOR TYPE, 2013–2022 (USD MILLION)

Processor Type	2013	2014	2015	2016-e	2018-p	2020-p	2022-p	CAGR (2016–2022)
Microcontrollers	332.6	377.9	419.6	463.1	497.0	524.6	542.8	2.7%
DSP	75.2	87.8	108.2	128.3	169.9	184.3	191.1	6.9%
FPGA	17.2	24.5	29.8	46.4	56.1	58.6	57.7	3.7%
Memory Chips	3.8	4.5	5.5	6.6	8.7	9.4	9.8	6.9%
Total	428.8	494.7	563.2	644.4	731.8	776.9	801.4	3.7%

Here, they break out the hardware in US dollars and millions for microcontrollers,

Industrial / Manufacturing (con't)

- "Internet of Things (IoT) in the industrial sector has given rise to a new concept known as Industrial Internet of Things (IIoT), also known as **Industrial Internet** and **Industry 4.0. IIoT refers to the devices, sensors, actuators, and software that enable connectivity between machines.** Industrial Internet of Things consists of a large number of components ranging from sensors to micro-controllers and networking devices. These components are now being manufactured using advanced technologies allowing them to be continuously (and wirelessly) connected to the Internet. The Internet of Things market in the **industrial sector is expected to grow at an exponential rate** and this can be gauged from the fact that many industry leaders such as GE, AT&T, Cisco, Intel, and IBM collectively formed the Industrial Internet Consortium in 2014. According to each of these previously mentioned companies, IoT in the industrial sector presents an even bigger market growth opportunity than that in the consumer sector."
- http://www.iiconsortium.org (remember we saw OIC last week)

They form this open Internet.

Industrial / Manufacturing (con't)

TABLE 37 IOT TECHNOLOGY MARKET FOR INDUSTRIAL MOTE APPLICATION, BY OFFERING, 2013–2022 (USD BILLION)

Offering	2013	2014	2015	2016-e	2018-p	2020-p	2022-p	CAGR (2016–2022)
Platform, Software, and Services	8.73	11.77	16.44	20.69	34.63	62.46	112.77	32.7%
Hardware	0.11	0.15	0.17	0.20	0.25	0.30	0.32	8.1%
Total	8.85	11.91	16.61	20.89	34.88	62.76	113.09	32.5%

that was listed between another set of companies that we saw last week.

Industrial / Manufacturing (con't)

FIGURE 47 PROCESSOR SEGMENT TO GROW AT THE HIGHEST RATE IN THE IOT TECHNOLOGY MARKET FOR INDUSTRIAL APPLICATION

	Sensors	Connectivity Chips	Processors
2016-e	85.9	95.0	22.0
2022-p	145.5	132.5	45.8
CAGR (2016-2022)	9.2%	5.7%	13.0%

Here in the industrial sector,

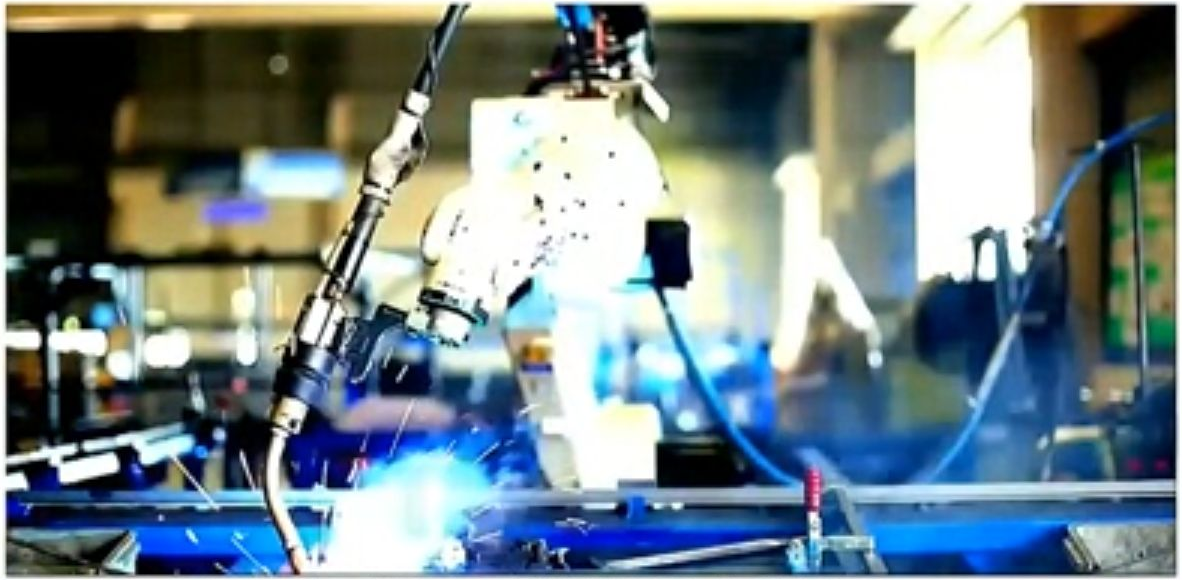
Industrial / Manufacturing (con't)

TABLE 42 IOT TECHNOLOGY MARKET FOR INDUSTRIAL APPLICATION, BY CONNECTIVITY TECHNOLOGY, 2013–2022 (USD MILLION)

Connectivity Technology	2013	2014	2015	2016-e	2018-p	2020-p	2022-p	CAGR (2016–2022)
ZigBee	17.7	22.6	27.3	31.9	40.7	48.9	55.4	9.7%
WHART	24.0	27.3	29.5	31.1	33.1	33.7	33.0	1.0%
Wi-Fi	3.4	4.2	4.9	5.6	6.7	7.6	8.0	6.2%
Bluetooth	1.3	1.8	2.4	3.0	4.3	5.6	6.9	14.8%
Others	13.3	17.2	20.6	23.4	27.5	29.5	29.2	3.7%
Total	59.7	73.2	84.7	95.0	112.3	125.3	132.5	5.7%

Here, they have these connectivity technologies and we will look at

Manufacturing Example



- Source: https://www.youtube.com/channel/UCyz6-taovlaOkPsPtK4KNEg?v=QmDR29YNKqc

between consumers and partly with equipment manufacturers.

Manufacturing Example

- What did we learn?
- 1/2 trillion $US in savings
- Split between consumers and equipment manufacturers
- 3 characteristics
  - Virtualization of a product/process
  - More human to machine collaboration (Co-bots)
  - Real-time communications between enterprise systems and the factory floor (IT merged with OT)
- Impacts to labor: Location agnostic, demand and supply chain, rather than labor costs

Impacts to labor: location agnostic.

Building Automation (con't)

- "The demand for energy-efficient solutions, enhanced security, increased venture capital funding, and the constant need for improving the standards of the individuals has led to the development of the building automation market. Building automation, which started with wired technology, has now entered the era of wireless technology with technologies such as ZigBee, Z-wave, EnOcean, Wi-Fi, and Bluetooth Smart revolutionizing the market. The growing awareness toward energy conservation, stringent legislations, and building directives, promotion of numerous smart grid technologies, and the availability of a number of open protocols are further driving the growth of the building automation market."

Building Automation (con't)

- Device types:
  - Occupancy sensors
  - Daylight sensors
  - Thermostats
  - Cameras
  - Power meters
  - Locks
  - Smoke / gas detectors
  - Lighting control actuators

in, Building for building automation?

Building Automation (con't)

- Device types:
  - Occupancy sensors
  - Daylight sensors
  - Thermostats
  - Cameras
  - Power meters
  - Locks
  - Smoke / gas detectors
  - Lighting control actuators

What are the kind of sensors and actuators can you think over that might be deployed

Building Automation (con't)

TABLE 28 IOT TECHNOLOGY MARKET FOR BUILDING AUTOMATION , BY OFFERING, 2013–2022 (USD BILLION)

Offering	2013	2014	2015	2016-e	2018-p	2020-p	2022-p	CAGR (2016-2022)
Platform, Software, and Services	7.89	10.58	14.72	18.43	30.55	54.63	97.63	32.0%
Hardware	0.71	0.90	1.15	1.45	2.01	2.46	2.91	12.4%
Total	8.60	11.48	15.86	19.87	32.55	57.09	100.55	31.0%

Building Automation (con't)

FIGURE 43 PLATFORM, SOFTWARE SOLUTIONS, AND SERVICES TO DOMINATE THE IOT TECHNOLOGY MARKET FOR BUILDING AUTOMATION APPLICATION DURING THE FORECAST PERIOD

	Platform, Software, and Services	Hardware
2016-e	18.43	1.45
2022-p	97.63	2.91
CAGR (2016–2022)	32.0%	12.4%

[LAUGH] This has grown by 32%, which is quite a bit.

Building Automation (con't)

FIGURE 45 ENOCEAN TO GROW AT THE HIGHEST RATE IN THE IOT TECHNOLOGY MARKET FOR BUILDING AUTOMATION APPLICATION

	Others	Cellular	ZigBee	Ethernet	EnOcean	NFC	Bluetooth
2016-e	54.6	41.9	42.9	34.1	3.1	5.1	0.6
2022-p	144.1	97.3	79.9	62.9	14.1	11.8	2.3
CAGR (2016-2022)	17.5%	15.1%	10.9%	10.7%	29.1%	14.9%	25.9%

It predict the EnOcean technology
will grow at the highest rate

Building Automation (con't)

TABLE 34 IOT TECHNOLOGY MARKET FOR BUILDING AUTOMATION APPLICATION, BY CONNECTIVITY TECHNOLOGY, 2013–2022 (USD MILLION)

Connectivity Technology	2013	2014	2015	2016-e	2018-p	2020-p	2022-p	CAGR (2016-2022)
ZigBee	108.3	125.4	144.0	164.2	201.1	230.2	257.3	7.8%
Ethernet	53.4	62.5	70.9	78.9	95.0	110.3	123.9	7.8%
Cellular	38.1	45.6	53.3	61.1	78.6	98.5	119.2	11.8%
EnOcean	16.0	22.7	31.0	41.3	68.5	106.5	157.7	25.0%
NFC	1.5	1.7	2.0	2.2	2.8	3.3	3.9	9.7%
Bluetooth	0.2	0.4	0.6	0.8	1.3	1.9	2.5	19.6%
Others	33.9	59.6	99.6	153.3	251.2	327.9	409.7	17.8%
Total	251.4	317.9	401.3	501.9	698.6	878.7	1074.1	13.5%

Building Automation Example

Source: https://www.youtube.com/watch?v=d55rBuB9D7s

Businesses are looking to save cost, reduce, Their overhead.

Oil and Gas (con't)

- "IoT-based technology solutions and related services are being increasingly implemented in the oil & gas application. The solutions are primarily aimed at achieving convergence of machines and intelligent data to enhance the operational efficiency targets being set by the energy companies. The solutions also improve the analytics-based decision making by diminishing the threats and vulnerabilities of the market (oil and gas market) by the use of efficient tools and techniques. Benefits include an increase in overall operational efficiency, cost-cutting, optimization of supply chain, diminishing the energy trading risk factors, and data privacy and security of all the affiliated industries spanning across the entire energy industry value chain."

Here's what the market research folks had to say about the oil and gas segment,

Oil and Gas (con't)

TABLE 66 IOT TECHNOLOGY MARKET FOR OIL & GAS APPLICATION, BY OFFERING, 2013–2022 (USD BILLION)

Offering	2013	2014	2015	2016-e	2018-p	2020-p	2022-p	CAGR (2016–2022)
Platforms, Software Solutions, and Services	6.78	9.17	12.87	16.26	27.44	49.89	90.81	33.2%
Hardware	0.20	0.26	0.31	0.36	0.45	0.63	0.79	14.0%
Total	6.98	9.43	13.18	16.62	27.89	50.52	91.60	32.9%

So, here's some info on their expectations in this segment.

Oil and Gas (con't)

FIGURE 60 SOFTWARE SOLUTIONS SEGMENT TO DOMINATE THE IOT TECHNOLOGY MARKET FOR OIL & GAS APPLICATION

	Software Solutions	Services	Platform
2016-e	8.38	7.21	0.67
2022-p	45.13	42.54	3.14
CAGR (2016–2022)	32.4%	34.4%	29.2%

So, here are those similar graphs that we saw on Tuesday.

Oil and Gas (con't)

FIGURE 59 LEVEL SENSORS TO DOMINATE THE SENSOR SEGMENT OF THE IOT TECHNOLOGY MARKET FOR OIL AND GAS APPLICATION

	Level sensors	Flow Sensors	Temperature Sensors	Pressure sensors	Others
2016-e	180.7	112.0	33.3	30.2	3.3
2022-p	396.7	244.0	76.4	68.0	4.0
CAGR (2016-2022)	14.0%	13.9%	14.8%	14.5%	3.2%

They took a look at the various sensors used in the oil and gas level sensors.

Oil and Gas Example

Source: GE: https://www.youtube.com/watch?v=KOq_4GANhdY

The machines are talking.

Oil and Gas (con't)

- GE - What did we learn?
- Centered around customer intimacy, driving outcomes
- 3 pillars
  - Smart sensors
  - Big data analytics
  - Deep domain knowledge
  - Combine these 3 => production optimization, more up-time
- Prediction
- Iterating with customers, not just a single point (end) solution, building integrated systems where all data can be shared and analyzed.
- Help customers get better at what they do.
- Help customers improve revenue and cash flow.

They want to help customers improve their revenue and their cash flow.

Agriculture (con't)

- "IoT technology can assist farmers by performing important tasks such as analyzing the water consumption level, providing animal alerting service, analyzing soil conditions based on fertilizers, and monitoring crop status. The increasing adoption of technology in agriculture and global rise in the demand for food are the major drivers for the growth of smart farming. IoT also helps to enhance the production and yield, by providing real-time data of the farm land to assist in planning, purchasing, inventory control, planting, and harvesting. Sensors, irrigation control, variable rate technology (VRT), and other technologies help to reduce the wastage of input and enhance the productivity of land."

important tasks such as analyzing the water consumption level,

Agriculture (con't)

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- VRT see: http://www.aces.edu/anr/precisionag/VRT.php

find out more about variable rate technology.

Agriculture (con't)

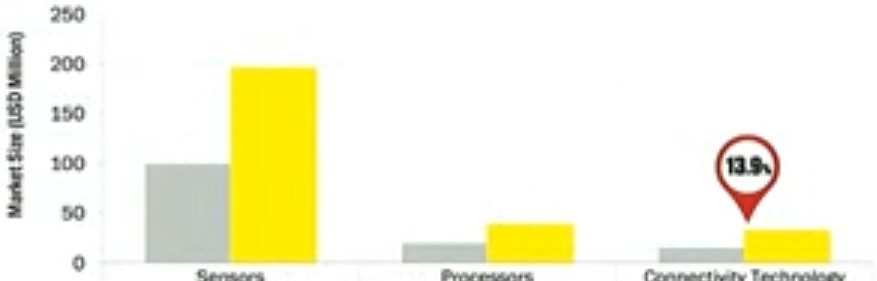
TABLE 71 IOT TECHNOLOGY MARKET FOR AGRICULTURE APPLICATION, BY OFFERING, 2013–2022 (USD BILLION)

Offering	2013	2014	2015	2016-e	2018-p	2020-p	2022-p	CAGR (2016–2022)
Platform, Software, and Services	2.96	4.00	5.62	7.09	11.96	21.74	39.55	33.2%
Hardware	0.04	0.08	0.11	0.13	0.18	0.23	0.27	12.2%
Total	3.00	4.08	5.72	7.23	12.14	21.96	39.82	32.9%

software, and services, much larger than the hardware in terms of revenue.

Agriculture (con't)

FIGURE 61 CONNECTIVITY TECHNOLOGY SEGMENT TO GROW AT THE HIGHEST RATE IN THE IOT TECHNOLOGY MARKET FOR AGRICULTURE APPLICATION



	Sensors	Processors	Connectivity Technology
2016-e	99.5	19.8	15.1
2022-p	196.6	38.8	33.0
CAGR (2016-2022)	12.0%	11.9%	13.9%

the connectivity technology segment to grow at the highest rate,

Agriculture (con't)

TABLE 74 IOT TECHNOLOGY MARKET FOR AGRICULTURE APPLICATION, BY SENSOR TYPE, 2013–2022 (USD MILLION)

Sensor Type	2013	2014	2015	2016-e	2018-p	2020-p	2022-p	CAGR (2016-2022)
Humidity Sensors	9.8	17.1	23.6	29.4	39.2	47.3	54.1	10.7%
Soil Temperature Sensors	4.9	8.8	12.5	15.9	22.2	27.8	32.8	12.8%
Soil Humidity Sensors	3.3	6.0	8.5	11.0	15.6	19.7	23.6	13.6%
Pressure Sensors	3.8	6.6	9.2	11.5	15.5	18.8	21.7	11.2%
Temperature Sensors	0.2	0.4	0.5	0.7	1.0	1.2	1.4	12.8%
Others	9.6	17.3	24.4	31.0	43.0	53.6	63.0	12.5%
Total	31.6	56.2	78.7	99.5	136.5	168.5	196.6	12.0%

pressure sensors, and temperature sensors.

Agriculture (con't)

FIGURE 62 GNSS MODULES TO GROW AT THE HIGHEST RATE IN THE IOT TECHNOLOGY MARKET FOR AGRICULTURE APPLICATION

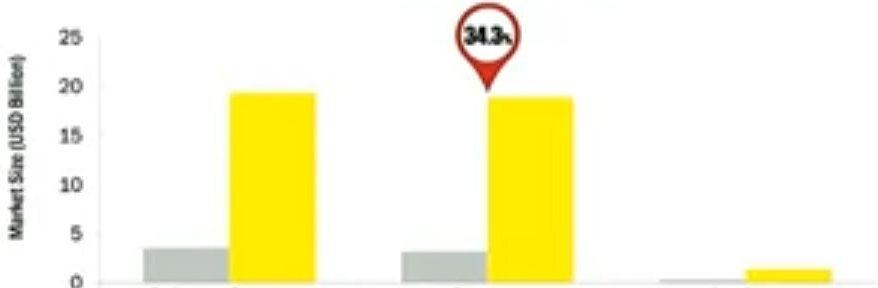
	GNSS Modules	ZigBee	Cellular	Wi-Fi	Bluetooth Smart/BLE	Others
2016-e	5.1	1.7	1.2	0.8	0.6	5.7
2022-p	12.1	2.9	2.5	1.4	1.0	13.2
CAGR (2016-2022)	15.4%	9.3%	13.6%	8.4%	9.5%	14.9%

GNSS = Global Navigation Satellite System (GPS, GLONASS, Galileo, Beidou

So, think GPS, GPS modules.

Agriculture (con't)

FIGURE 63 SOFTWARE SOLUTIONS SEGMENT TO HOLD THE LARGEST SIZE OF THE IOT TECHNOLOGY MARKET FOR AGRICULTURE APPLICATION



	Software Solutions	Services	Platform
2016-e	3.58	3.22	0.29
2022-p	19.34	18.87	1.35
CAGR (2016-2022)	32.4%	34.3%	29.2%

Services also, dramatically, and they were predicting not a lot of

Operating Systems (con't)

- Their are many contenders, where to start?
- informationweek.com list of top-8:
  - RIOT
  - Windows 10
  - VxWorks
  - Google Brillo
  - ARM Mbed
  - Apple iOS and Mac OS X
  - Mentor Graphics Nucleus RTOS

I've used Mentor Graphics products as part of chip design for years at various points,

Operating Systems (con't)

- Their are many contenders, where to start?
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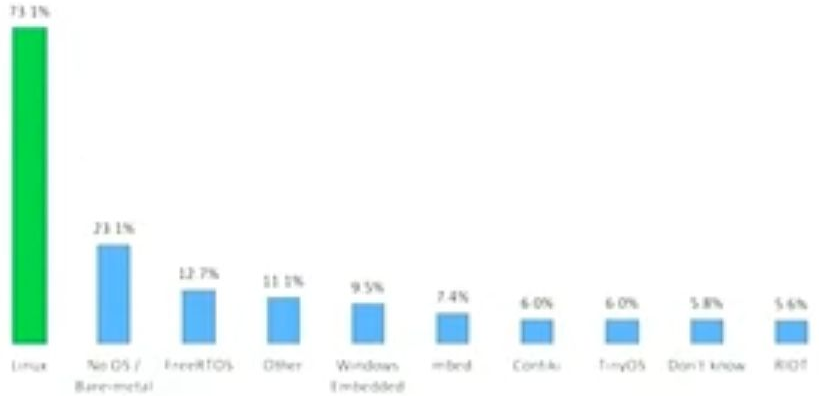
  - RIOT
  - Windows 10
  - VxWorks
  - Google Brillo
  - ARM Mbed
  - Apple iOS and Mac OS X
  - Mentor Graphics Nucleus RTOS
  - Greenhills Integrity

Greenhills Integrity, Arrow Electronics is heavily involved in helping companies

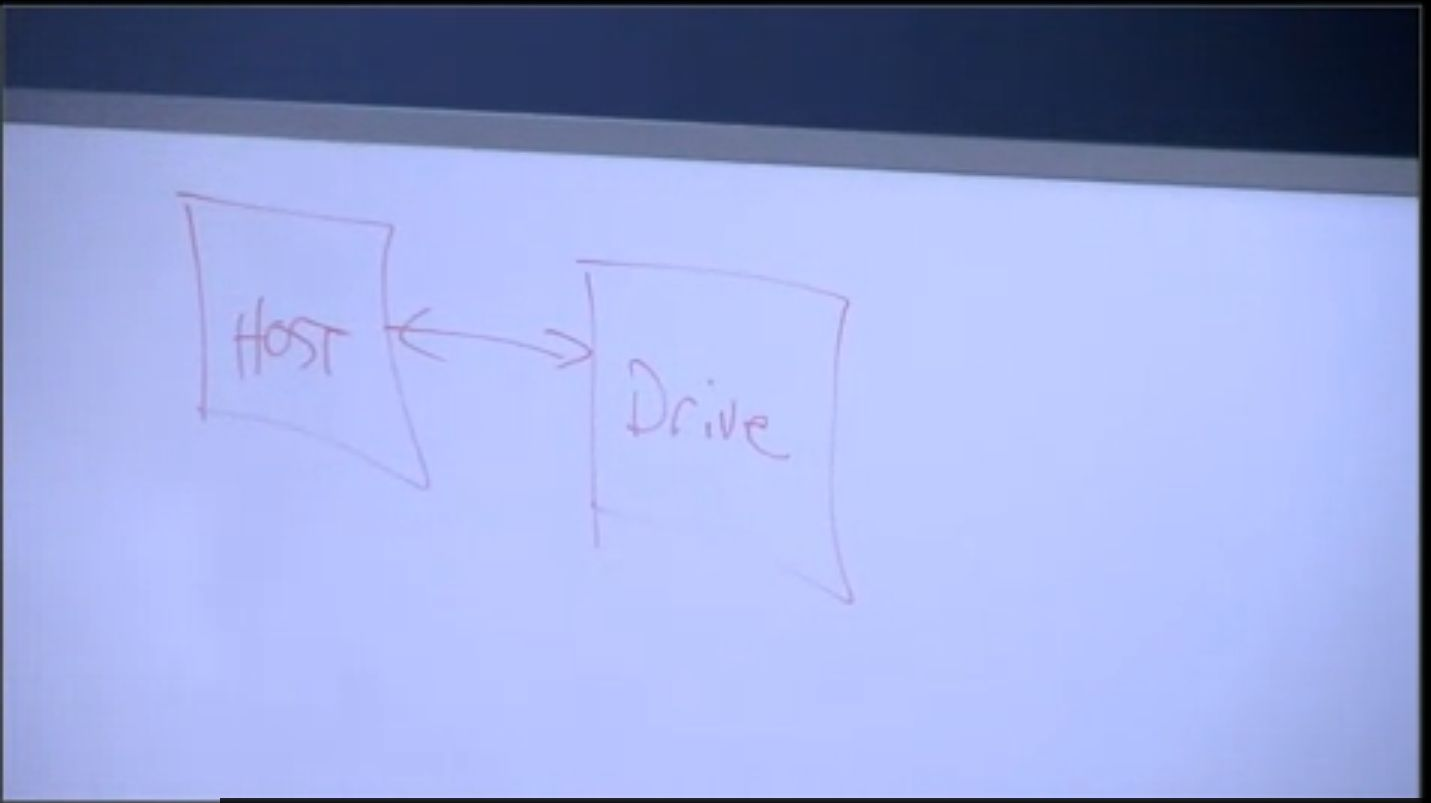
Operating Systems (con't)

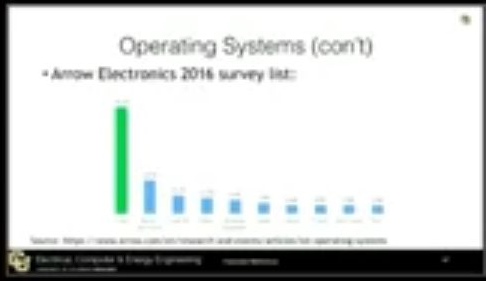
- Arrow Electronics 2016 survey list:



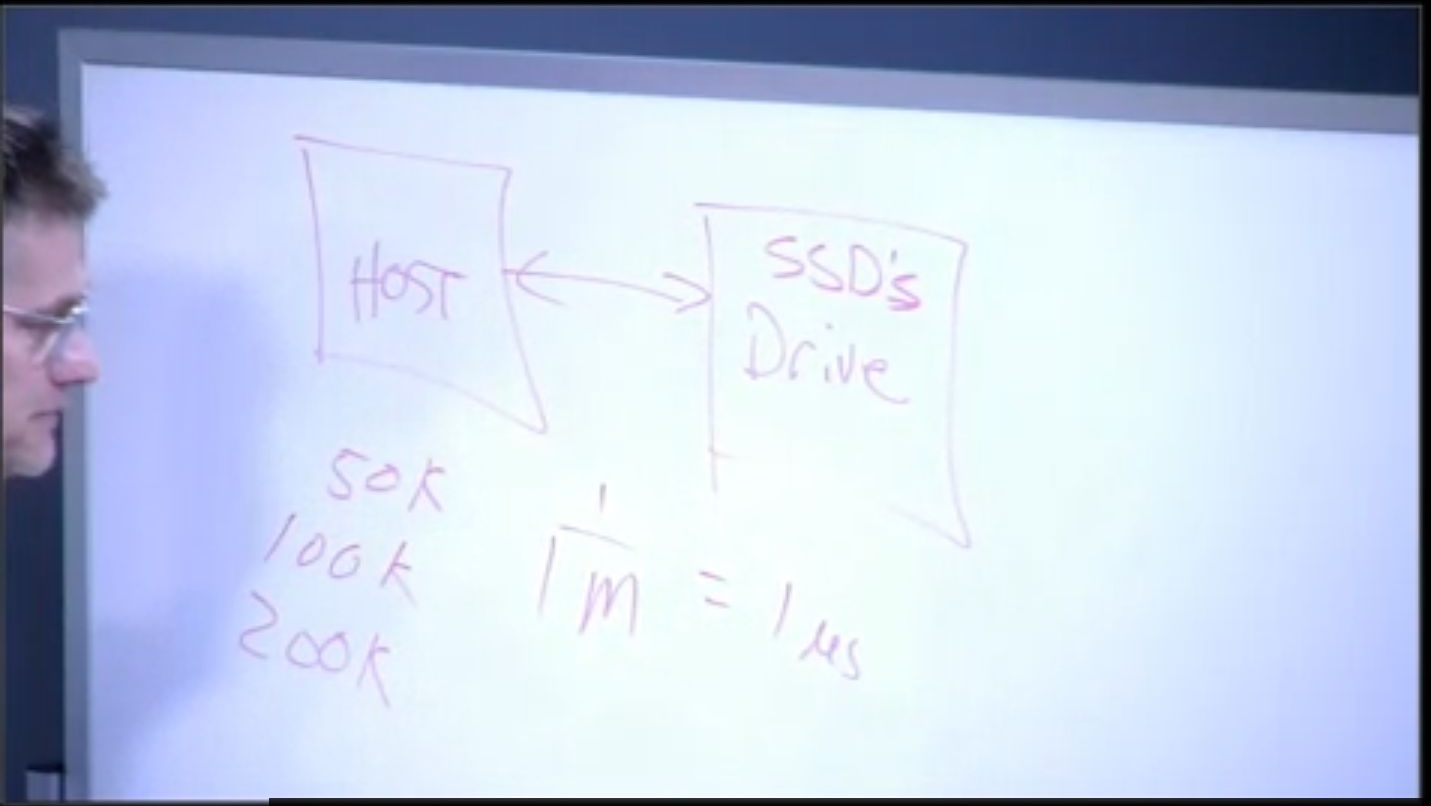
Source: https://www.arrow.com/en/research-and-events/articles/iot-operating-systems

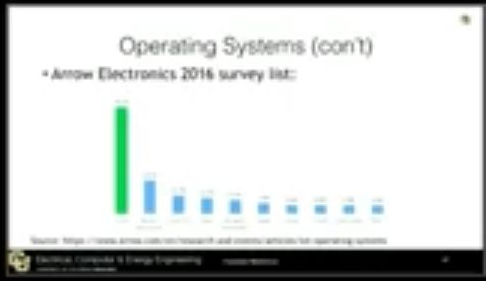
Greenhills Integrity, Arrow Electronics is heavily involved in helping companies





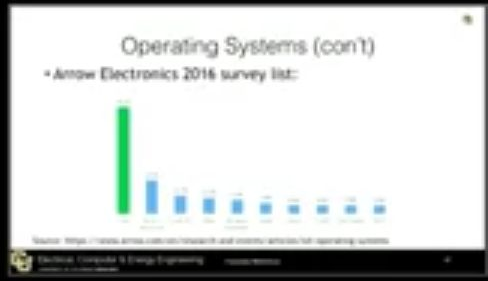
they can be 512 byte blocks or they can be 4,096 byte blocks,



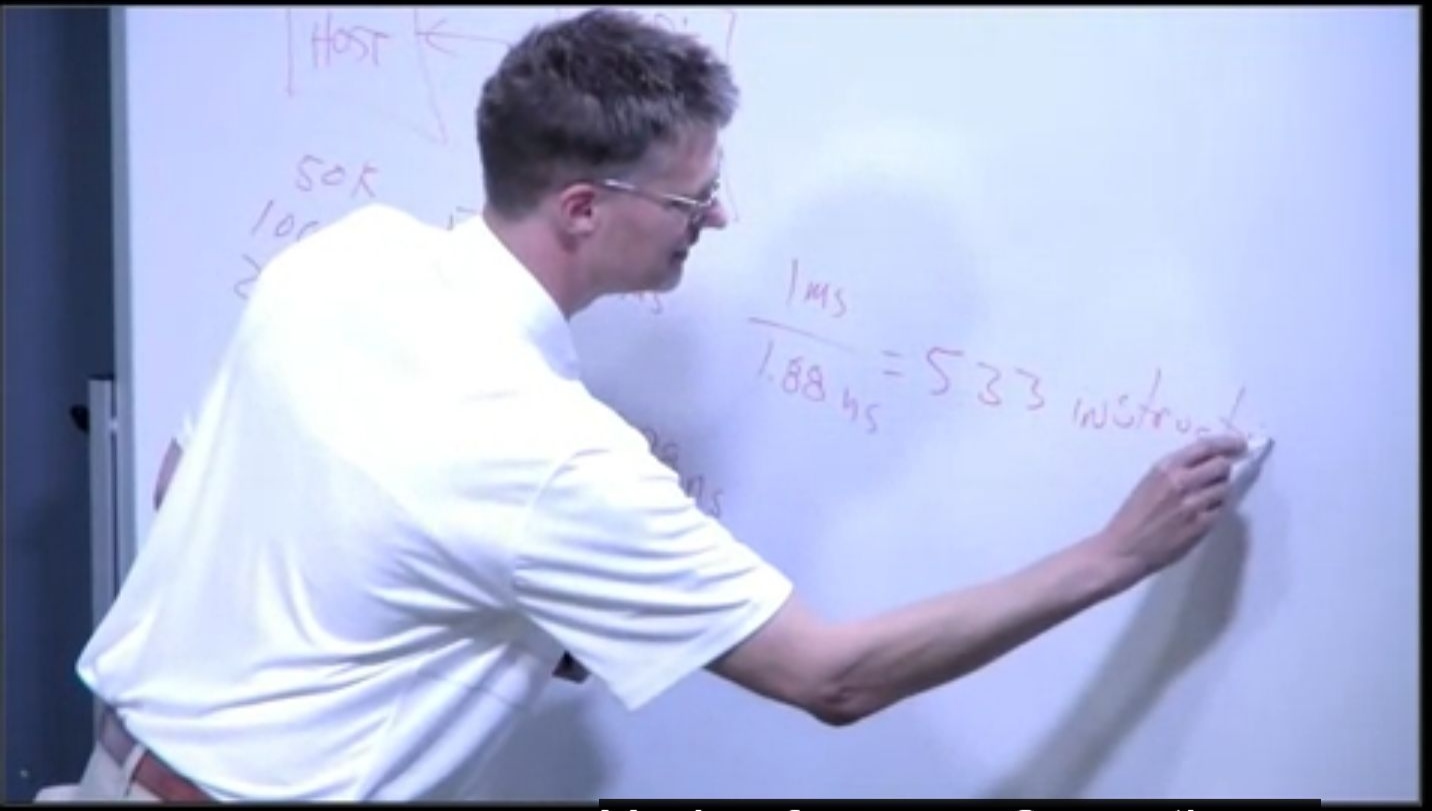


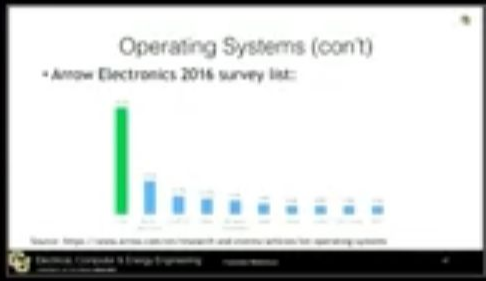
you get one over one million is equal to one microsecond.

50k
100k
200k
1/M = 1 µs
533MHz = 1.88ns



imagine your CPU is able to execute one instruction per clock.





Yeah, of course. Currently, we

Operating Systems (con't)

Table 1: Overview of Potential Open-Source OSes for IoT Sensor Nodes

	Contiki	RIOT	FreeRTOS	TinyOS	uClinux	Mbed
Architecture	monolithic	microkernel RTOS	microkernel RTOS	monolithic	monolithic	monolithic
Scheduler	cooperative	preemptive, tickless	preemptive, optional tickless	cooperative	preemptive	preemptive
Programming model	event-driven, protothreads	multi-threading	multi-threading	event-driven	multi-threading	Event driven, single-thread[2]
Targeted device class[1]	Class 0, 1	Class 1,2	Class 1,2	Class 0	>Class 2	Class 1,2
Supported MCU families or vendors	AVR[3], MSP430 TM, ARM[3] Cortex-M[3], PIC32, 6502	AVR[3], MSP430 TM, ARM[3] Cortex-M[3], x86	AVR[3], MSP430 TM, ARM[3], x86, 8052, Renesas	AVR[3], MSP430 TM, pic24ex	ARM7 TM, ARM[3] Cortex-M[3]	ARM[3] Cortex-M[3]
Programming languages	C	C, C++	C	nesC	C	C, C++
License	BSD	LGPLv2	modified GPL	BSD	GPLv2	Apache License 2.0

Source: https://www.arrow.com/en/research-and-events/articles/iot-operating-systems

It's an overview of potential open-source OSes for IoT sensor nodes.

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- businessofapps.com list:
  - Nano-RK
  - LiteOS
  - Nimbits
  - OpenAlerts
  - Thingssquare Mist
  - Thingsspeak (Arduino, Raspberry Pi)
  - IoT Toolkit
  - Nitrogen
  - Argot
  - dat

dat, this data is also from Arrow Electronics.

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- Embedded OS Considerations
  - Is real-time performance required?
  - Available hardware resources?: memory size, MMU, CPU capability
  - Security requirements ?
  - How is the device powered?
  - Communication and network requirements?
  - Ability to interface to an enterprise-wide system?

Source: https://www.arrow.com/en/research-and-events/articles/iot-operating-systems

To RTOS or Not?

Often in the embedded world the question of using a Real-Time Operating System (RTOS) or not, is the big question amongst engineers. The answers found on-line are usually biased opinions without metrics or scientific support of the argument. They usually state the advantages or disadvantages over the classic round-robin systems. The truth is that engineers, prefer and like evidence instead of heuristics. I will try to answer this, as I did for myself. I believe this small guide will help decide if an RTOS is worth the effort or not.

Seems that there is no specific engineering parameter that would pin-point if we really need an RTOS or not. But let's go back to the principles of decision. What all systems try to do? Share the CPU time resource. Is RTOS better in schedulability in respect to the other non pre-emptive systems? Actually real-time systems do not care of better or faster. They care of deterministic responses.

There is a very good principle that helps us in general with schedulability. This is called Rate-Monotonic Approach (RMA). This method analyses a system to check if it is possible to schedule its tasks. The inputs are various parameters like period of events, sporadic events, deadlines, etc. that helps derive mathematically if the system is schedulable. This approach works with fixed-priority schemes and with either pre- emptive or non pre-emptive systems.

Thus the methodology would be to estimate each tasks worst execution time, gather all the deadlines, fill in the matrices and get a result if the specific system is schedulable. Analyzing the round-robin systems first, you get the idea if this will work or you stress the system.

The question to place an RTOS or not can be greatly answered depending on schedulability. If the system can be scheduled without an RTOS safely then you do not need an RTOS. If not, then RTOS is the way to go. Of course there can be other reasons for the decision, like future expansion, ready stacks to use etc. but these goes beyond the basic principles of decision. You may use the RMA method to provide the criteria for your decision.

Source: Ilias Alexopoulos on LinkedIn

This gentleman on LinkedIn wrote this paper and I snatched it up I