

Access to Course Resources

<https://www.coursera.org/learn/industrial-iot-markets-security/resources/l3ari>

Course Overview (con't)

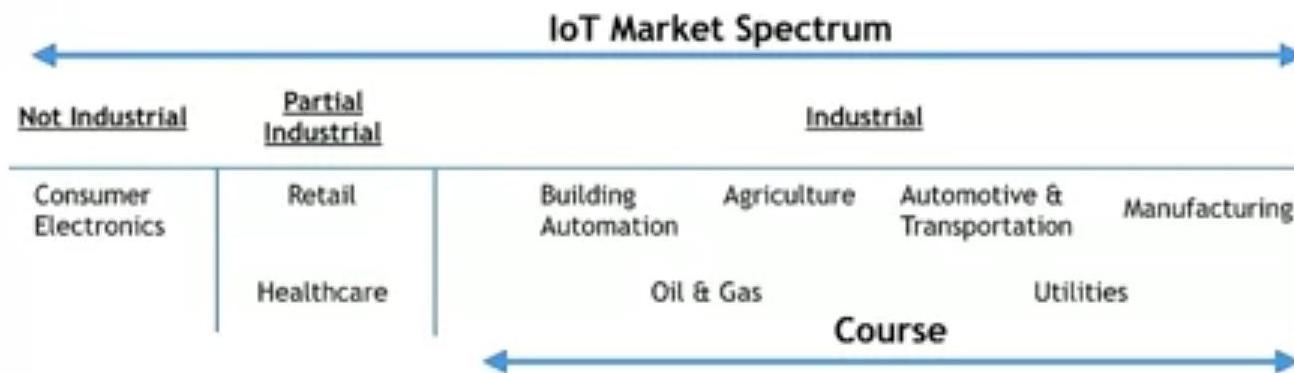
- Primary focus
 - Emerging trends: Market and Technical
 - Key business concepts for engineers
 - Key skills to develop
 - Understanding the “big picture”, how these systems are built and the value propositions they offer
 - Your role in DIoT - Show you how your ESE core and elective courses intersect with IIoT



This is transformation that's
taking place in the business and

Course Overview (con't)

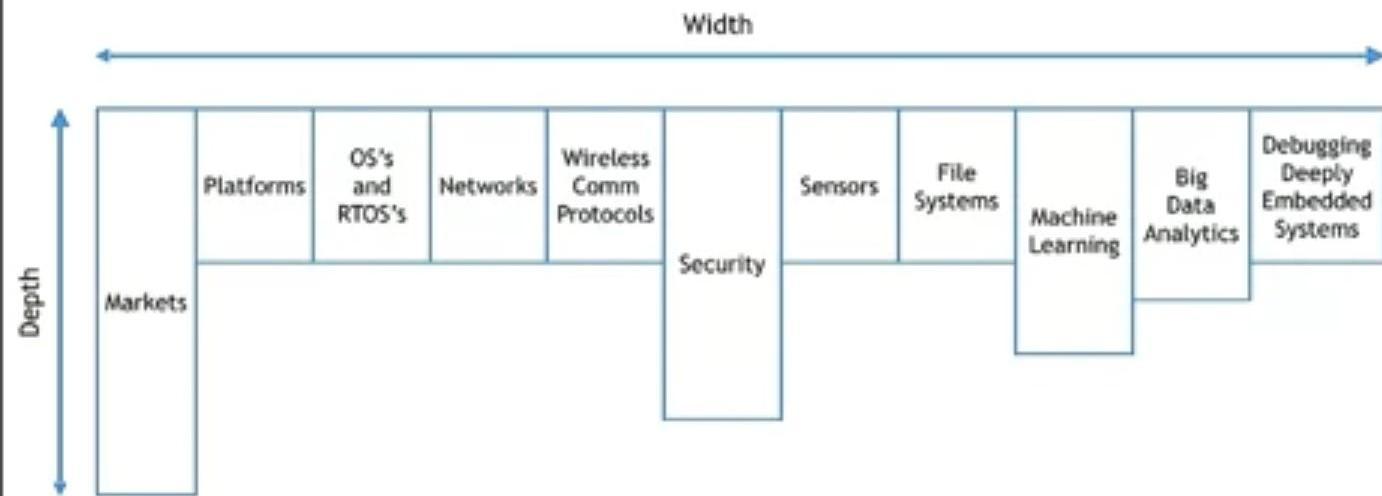
- What is Industrial IoT?



What I really consider industrial is application areas of building automation,



Topic Areas



I drew to try to give you an idea
of the concept behind this course.

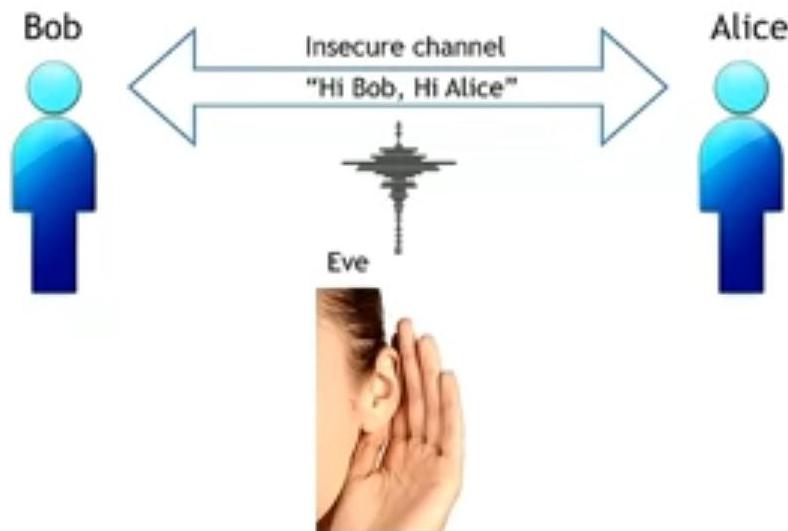
What will be covered

- An inside look at markets; size and \$ estimates
- Platforms, IBM Bluemix + Watson
- Networks, NFV and SDN
- Security
- Project planning, staffing and execution
- Sensors, file systems
- Machine learning
- Big data analytics
- SystemC
- Debugging deeply embedded systems
- Guest speakers



we used all Lauterbach equipment just because

What does it mean to be secure?



Alice and is trying to listen in on what's happening.

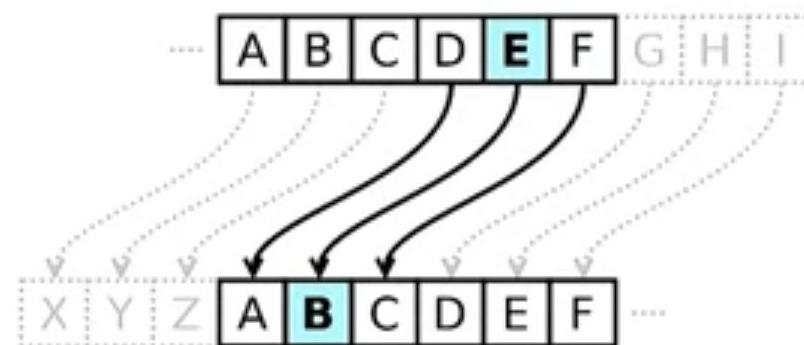
What does it mean to be secure?



so frustrated that Eve gives up and decides not to eavesdrop anymore.

Encryption Techniques

- Caesar Cipher, named after Julius Caesar



Long time ago, Julius Caesar created this Cipher,

Encryption Techniques

- One time pad (OTP)
- So-called “perfect” encryption



A=0, B=1, C=2, ... Z=25												
Plain text	M	E	E	T	T	O	N	I	G	H	T	
Key	12	4	4	19	19	14	13	8	6	7	19	
Sum	D	Z	H	S	U	I	M	W	E	K	C	
Sum mod 26	3	25	7	18	20	8	12	22	4	10	2	
Cipher Text	P	D	L	L	N	W	Z	E	K	R	V	
Cipher text	P	D	L	L	N	W	Z	C	K	R	V	
Key	15	29	11	37	39	22	25	30	10	17	21	
Diff	3	3	11	11	13	22	25	4	10	17	21	
Sum mod 26	P	D	L	L	N	W	Z	C	K	R	V	
Plain text	15	3	11	11	13	22	25	4	10	17	21	



the so-called "perfect" encryption because it is,

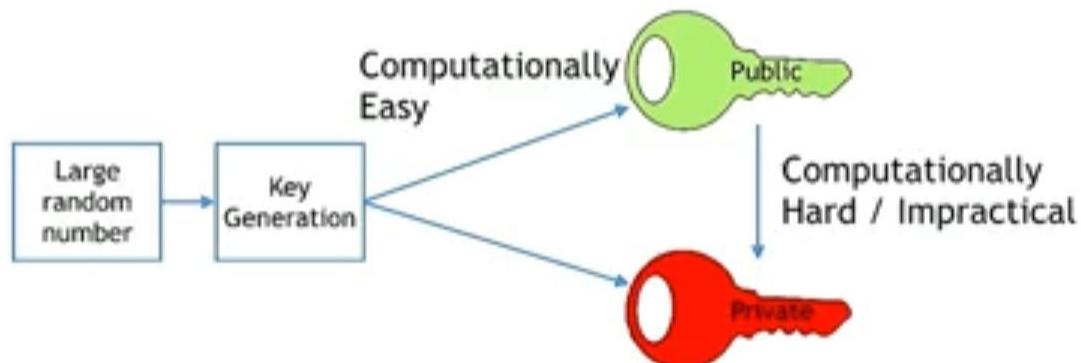
AES (Advanced Encryption Standard)

- Established by US NIST (National Institute of Standards)
- Block cipher: 16-bytes in, 16-byte out
- 3 key lengths: 128-, 192-, 256-bits
- High-level description
 - 1) With N =number of rounds, round keys are extracted from the cipher key (where $N = 10, 12, 14$, for 128-, 192- or 256-bits)
 - 2) Round 0
 - 3) Rounds 1 to $N-2$
 - 4) Final round $N-1$
- Believed to be secure, but we don't know how to prove it.



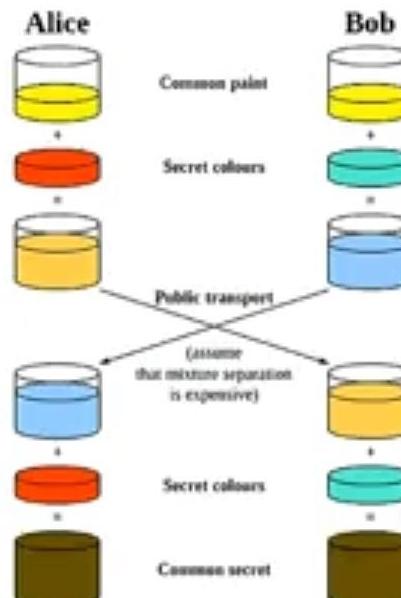
it's key lengths series of rounds it goes through to iterate as it scrambling the data,

Asymmetric Encryption



Diffie-Hellman

A method to securely establish a known secret (a "key") between 2 parties over an insecure channel.

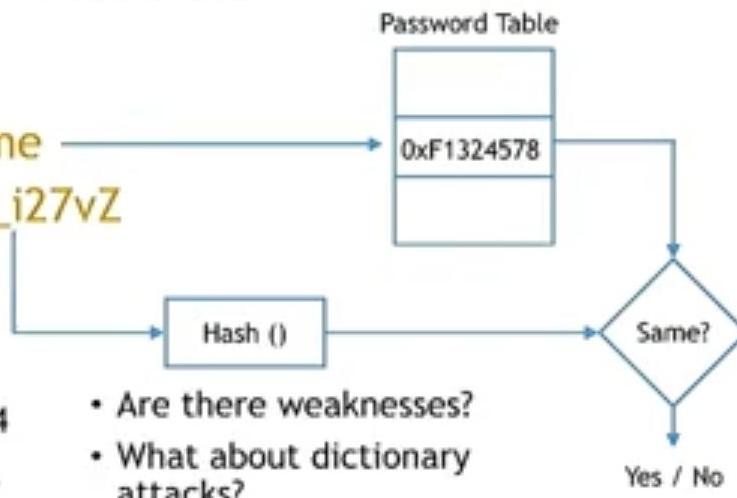


Source: https://en.wikipedia.org/wiki/Diffie-Hellman_key_exchange

or learn about Diffie-Hellman algorithm which is a way to

Uses for Hash Functions

- Saving passwords
 - Login: **UserName**
 - Password: **Xh8_i27vZ**



- See also the SHA-2 family of hash functions as per FIPS 180-4
- Well studied, haven't spotted a problem yet

- Are there weaknesses?
- What about dictionary attacks?



Take Aways

- Security Mind-set
- Data Integrity
- Authentication
- Encryption
- Will look at few “security blunders”



and it has all bunch of examples of security blunders,

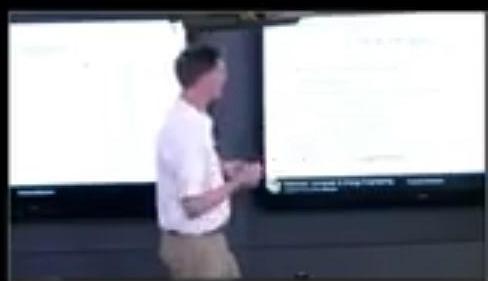
Example of supervised learning:

Linear Regression

- We have some example data
 - Training data
- Each row is an example from real sales data
- Contains a number of features, x_i
 - x_1 is square footage
 - x_2 is number of bedrooms
- And output y , the price
 - Is what we are trying to predict, also known as the target value

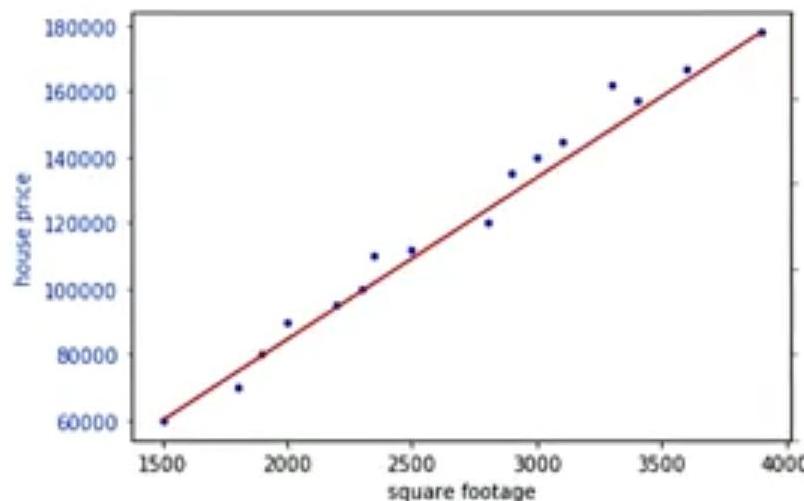


```
train_data = np.array(  
[  
    # sqft, #bedrooms, price  
    [1500, 2, 60000],  
    [1800, 2, 70000],  
    [1900, 2, 80000],  
    [2000, 3, 90000],  
    [2200, 3, 95000],  
    [2300, 2, 100000],  
    [2350, 3, 110000],  
    [2500, 3, 112000],  
    [2800, 4, 120000],  
    [2900, 3, 135000],  
    [3000, 4, 140000],  
    [3100, 4, 145000],  
    [3300, 5, 162000],  
    [3400, 4, 157000],  
    [3600, 5, 167000],  
    [3900, 5, 178000]  
]) # end training data
```



I guess this is like the kindergarten example,

We can manually draw a best-fit curve



We can draw a straight line through that,

Linear Regression

- m = number of training examples, 16
- n = number of features, 2
- We can rewrite $h_{\theta}(x)$ as :

$$\cdot h_{\theta}(x) = \sum_{i=0}^n \theta_i x_i = \theta^T x$$

$$\theta^T x = [\theta_0, \theta_1, \theta_2, \dots, \theta_n] [x_0 \\ x_1 \\ x_2 \\ \vdots \\ x_n]$$

x_0 a real number
 $x_1 = \mathbb{R} = h_{\theta}(x)$
 \vdots
 $x_n]$



So if we arrange right out



Linear Regression

- How do we pick/calculate/learn the values for the θ_i 's?
 - As a starting point, we can make $h(\cdot) \sim= y$
- We can define a **cost function**:
 - $J(\theta) = \frac{1}{2} \sum_{i=1}^m (h_\theta(x^{(i)}) - y^{(i)})^2$
 - The superscript i 's refer to training examples, not raise to a power!
- We want to choose θ to minimize $J(\theta)$
- To do so, let's use a search algorithm that starts with some initial guess for θ , and repeatedly changes θ to make $J(\theta)$ smaller, until we converge at a minimum $J(\theta)$ value.



This process uses or defines a cost function,

Linear Regression

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This process uses or defines a cost function,

Credits

- If not otherwise indicated, market data by Markets and Markets, “*IOT Technology Market Forecast till 2022*”
- Used with permission
- <http://www.marketsandmarkets.com>



Learning Outcomes

- Definition of Industry 4.0
- Understanding precursors / enabling factors
- Understanding business considerations
- Understanding benefits
- Understanding influencing factors, market dynamics, drivers, restraints, opportunities and challenges
- Understanding the technical proposition
- Understanding the growth potentials
- Understanding the application areas
- Learning who the top players are



there's so much growth there there's going to be

Highlights

- Cisco: Only 1% of the worlds devices are connected. Opportunity for new business to be created that can help industries derive value from all the new data that will be available.
- Shell Oil: Smart Wells: Downhole sensors, monitors reservoir dynamics: water flow, gas movement, pressure changes and compaction. Realized substantial savings.
- GE: Utilities suffer more than \$200B in annual electrical losses and theft. GE True Grid Provides situational awareness with actual line data, reduces financial risks by truing up conventional billing and Smart Meters data to actual consumption, pinpointing theft as well as meter/billing errors.

Source: McRock Capital



annual electrical losses due to theft, people stealing electricity.

Highlights (Con't)

- Executives must:
 - Increase production
 - Create hybrid business models
 - Fuel innovation
 - Transform the workforce
 - Rio Tinto's operations center in Perth Australia, equipment operators sit in a remote command center and work with data analysts to orchestrate the actions of huge drills, excavators, earth movers and dump trucks.

Source: Accenture



work with data analysts to orchestrate the actions of these huge drills and

Highlights (Con't)

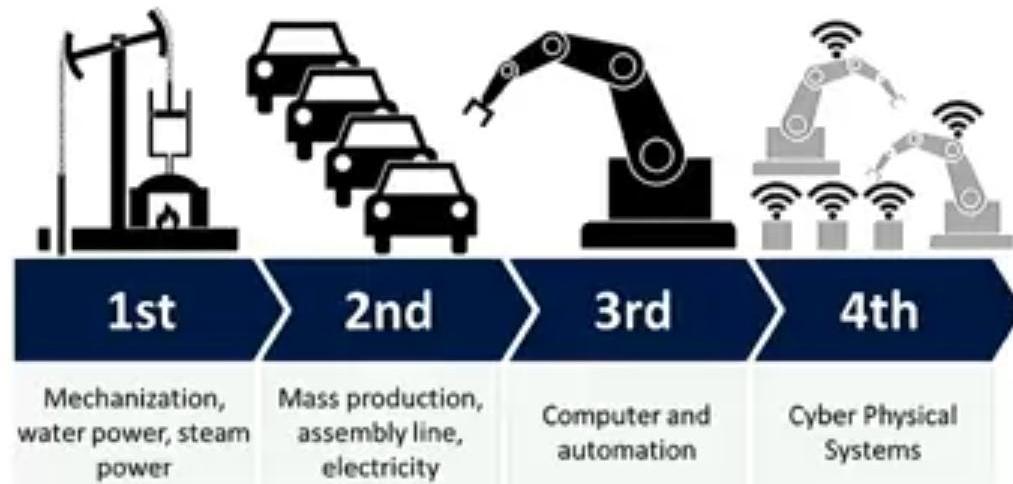
- Think unconventionally about what is valuable to customers
- *Be the most valuable information provider*
- 3 capabilities to master:
 - Intelligent machine applications



Source: Accenture

Three capabilities to master within the industrial IoT's basis,

Industry 4.0 - The 4th Industrial Revolution



Source: https://en.wikipedia.org/wiki/Industry_4.0

everybody, your brother goes there.



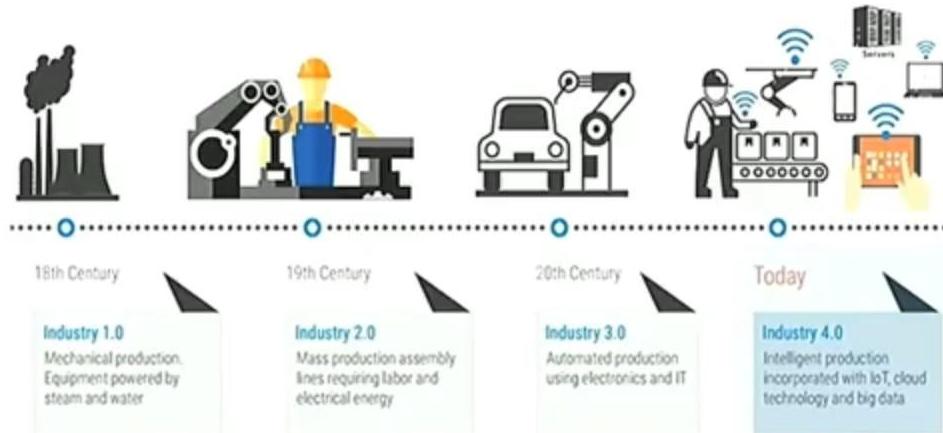
Industry 4.0 (con't)

- Industry 4.0 Workgroup
- 4 Design Principles
 - Interoperability: Connect and communicate via the Internet.
 - Information transparency: Ability to create a virtual copy of a physical system.
 - Technical assistance: Provide support to humans by aggregating information into visualizations, and perform operations that are unpleasant, too exhausting or unsafe.
 - Decentralized decisions: Ability of cyber physical systems (CPS) to make decisions on their own.



data from some sensors and making a decision all on it's

Industry 4.0 - A Brief History



Source: <https://www.youtube.com/watch?v=JCswJldVoXk>

So just a little background,

Industry 4.0 - A Brief History



IoT, Industry 4.0 and Smart Factory

Industrial Internet of Things (IIoT)

The explosion of the number of smart devices that are interconnected via the Internet. The IIoT is revolutionizing the way industry operates by sharing the information/data produced to improve existing business models and enable new ones.

Industry 4.0 (or Industrie 4.0)

A German term for the trend of automation and data exchange in manufacturing. It includes cyber-physical systems, the Internet of Things and cloud computing. Industry 4.0 creates what has been called a "smart factory."

Smart Factory

"Smart Manufacturing," "Intelligent Factory" and "Factory of the Future" all describe an intelligent, flexible and dynamic production facility, where machinery and equipment will have the ability to improve processes through self-optimization and autonomous decision-making.

Industry 4.0 is what most Europeans call it.

Industry 4.0 - A Brief History



Benefits of Industry 4.0/Smart Factories



Major Innovations in Digital Technology for Automation Provide Significant Benefits for the Manufacturing Sector, and Ultimately the Consumer

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BELDEN
DRIVING THE INDUSTRIAL REVOLUTION

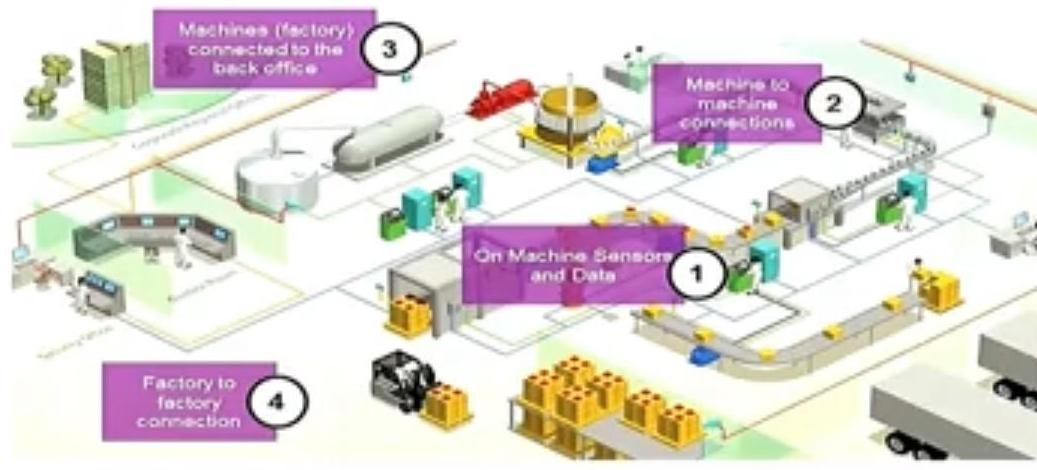
Source: <https://www.youtube.com/watch?v=JCswJldVoXk>

9

and it's predominantly improved productivity through

Industry 4.0 - A Brief History

The Smart Factory – Automated Systems & Processes



Source: <https://www.youtube.com/watch?v=JCswJldVoXk>

cycle time considerations in getting a product out of the factory is the amount

Industry 4.0 - A Brief History



Ethernet is the Technology that Will Enable....



Ethernet is Quickly Becoming the Choice For Data Networks Replacing Legacy Protocols Providing Significant Benefits, but It also Creates New Risks



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ce: <https://www.youtube.com/watch?v=JCswJldVoXk>

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Precursors / Enabling Factors

- IPv4 (2^{32} addresses) vs. IPv6 (2^{128} addresses = 340×10^{36} addresses)
- Dramatic reduction in costs: sensors, compute, network bandwidth, storage
- Dramatic reduction in power consumption for compute and wireless communication
- Dramatic reduction in size
- M2M communication has been present in manufacturing for over a decade
 - IIoT joins Operational Technology (OT) with Information Technology (IT) as a new network structure
 - IIoT connects this new network structure to the internet



That then enables remote access.

Precursors / Enabling Factors (con't)

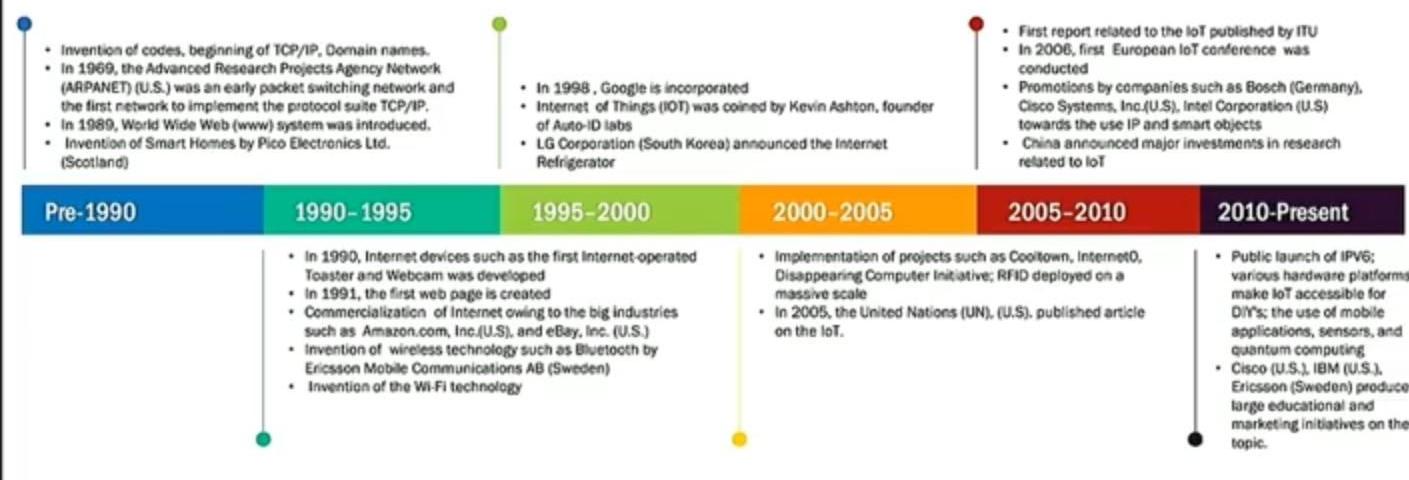
- Confluence of:
 - Sensor data
 - Machine Learning
 - Big Data analytics



We start to see a pattern here.

Evolution

FIGURE 17 IOT EVOLUTION



So back in around 2005,
right in this timeframe right here,

Business Considerations

- Business leaders witnessed the stability and maturity of the emerging solutions, tools and applications
 - => Reduces risk
- Solutions increase operational efficiencies
 - => Drives adoption
- Adopters want to see:
 - Increased profits
 - Increased revenue (sales)
 - Lower operational expenses



Influencing Factors Now

- Drivers
 - Increasing connectivity
 - Growing penetration of smart phones and other connected devices
 - Increasing adoption of wireless sensors
 - Mainstreaming of cloud computing
 - Machine Learning
 - Big Data Analytics
- Restraints
 - Lack of standards
 - Low power efficiency



I disagree with this as
a restraint just came out of

Influencing Factors Now (con't)

- Opportunities
 - Significant gov't funding
 - Innovative applications, development of comprehensive system solutions
- Challenges
 - Security
- Acquisitions, Alliances, Collaborations and partnerships
 - More than 50 deals in the last 3 years
- New product launches
 - Dozens of product/service launches in the last 3 years



products and service launches within
the last three years in the IoT space.

The power of 1%

- A small amount of operational efficiency gain can lead to significant savings
 - Airline fuel savings : saves \$30B
 - Gas-fired power generators : saves \$66B
 - Oil & Gas: Improve pump efficiency, increases 500K barrels a day => earn an additional \$19B
- => reduced costs
- => increased profit

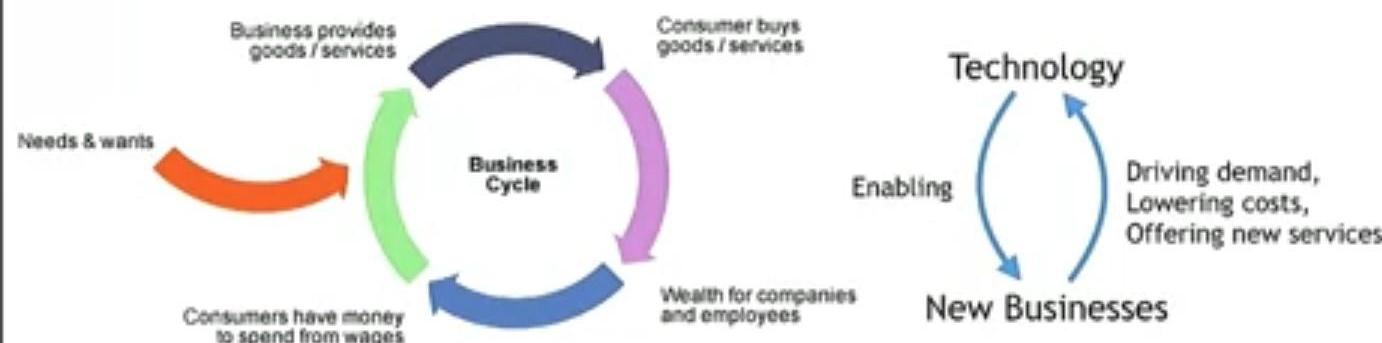


The Technical Proposition

- Smart machines are better than humans at accurately, consistently capturing and communicating data. This data can enable companies to identify inefficiencies and problems sooner, saving time and money and supporting business intelligence efforts.
- In manufacturing specifically, IIoT holds great potential for quality control, sustainable and green practices, supply chain traceability and overall supply chain efficiency.



Business Feedback Cycle

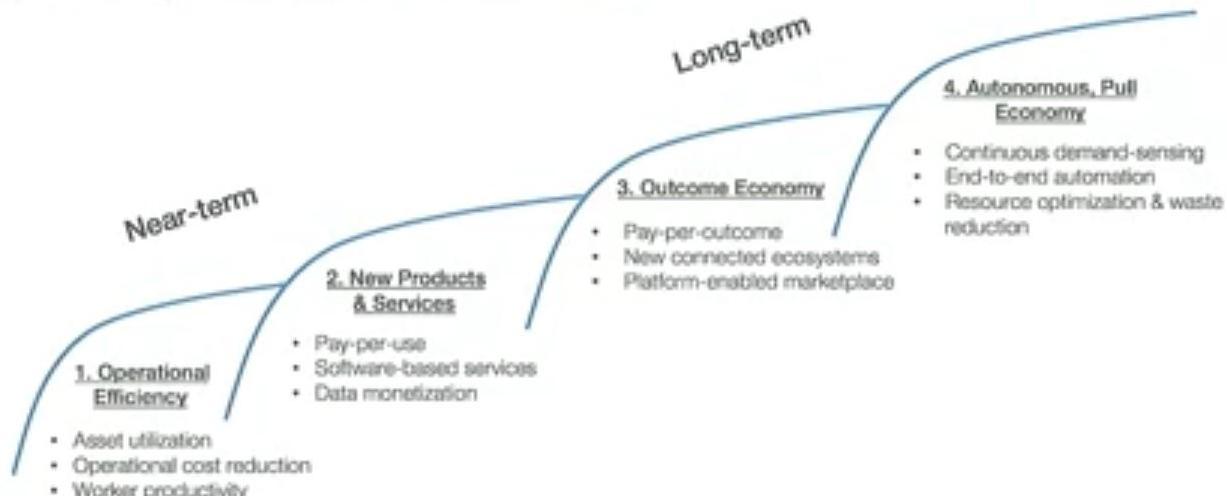


sector what's happened is technology is created that enables new businesses and



4 Phases of the Industrial Internet

Figure 1: The adoption and impact path of the Industrial Internet



Source: <https://www.rti.com/industries/iot-faq.html>

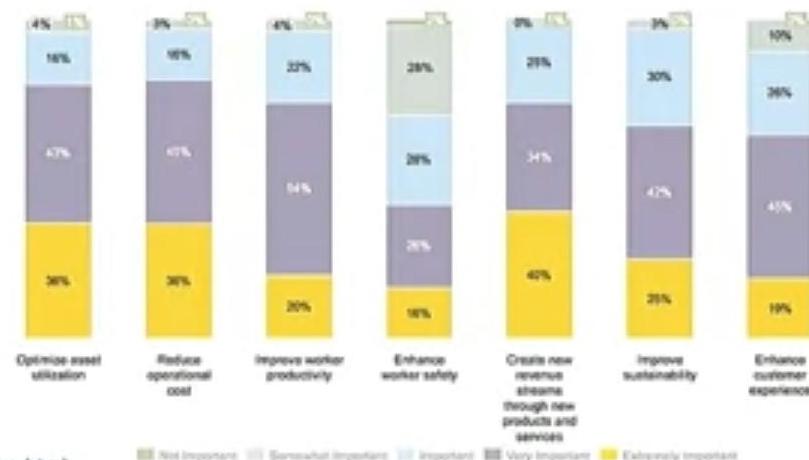


This is from RTI, this isn't from
the markets to markets report,

Business Benefits

Figure 2: Business benefits for driving near-term adoption

Q: How important are the following benefits in driving businesses to adopt the Industrial Internet?



Source: <https://www.rti.com/industries/iot-faq.html>

■ Not Important ■ Somewhat Important ■ Important ■ Very Important ■ Extremely Important

This again is from RTI,
they did a survey, asking many,

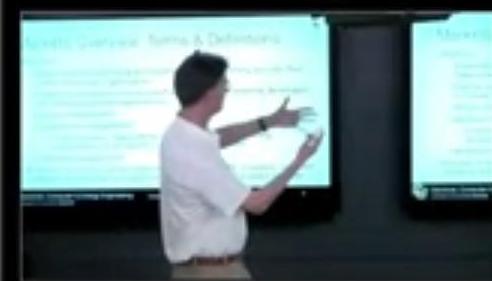
Market Overview: Terms & Definitions

- Hardware
 - Processors: CPU, MCU, FPGA, DSP and memory
 - Sensors
 - Connectivity: Bluetooth, WiFi, ethernet
- Software
 - Software solutions
 - Services
 - Platforms

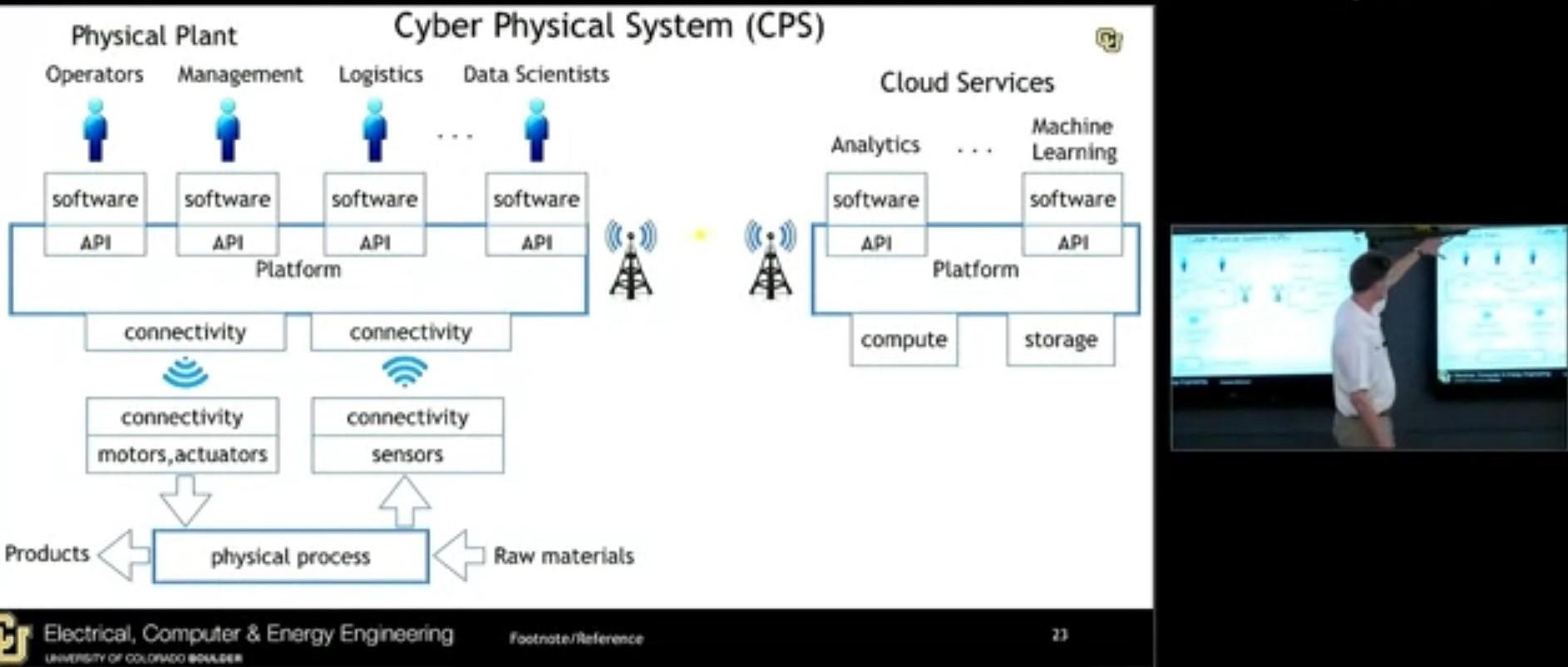


Markets Overview: Terms & Definitions

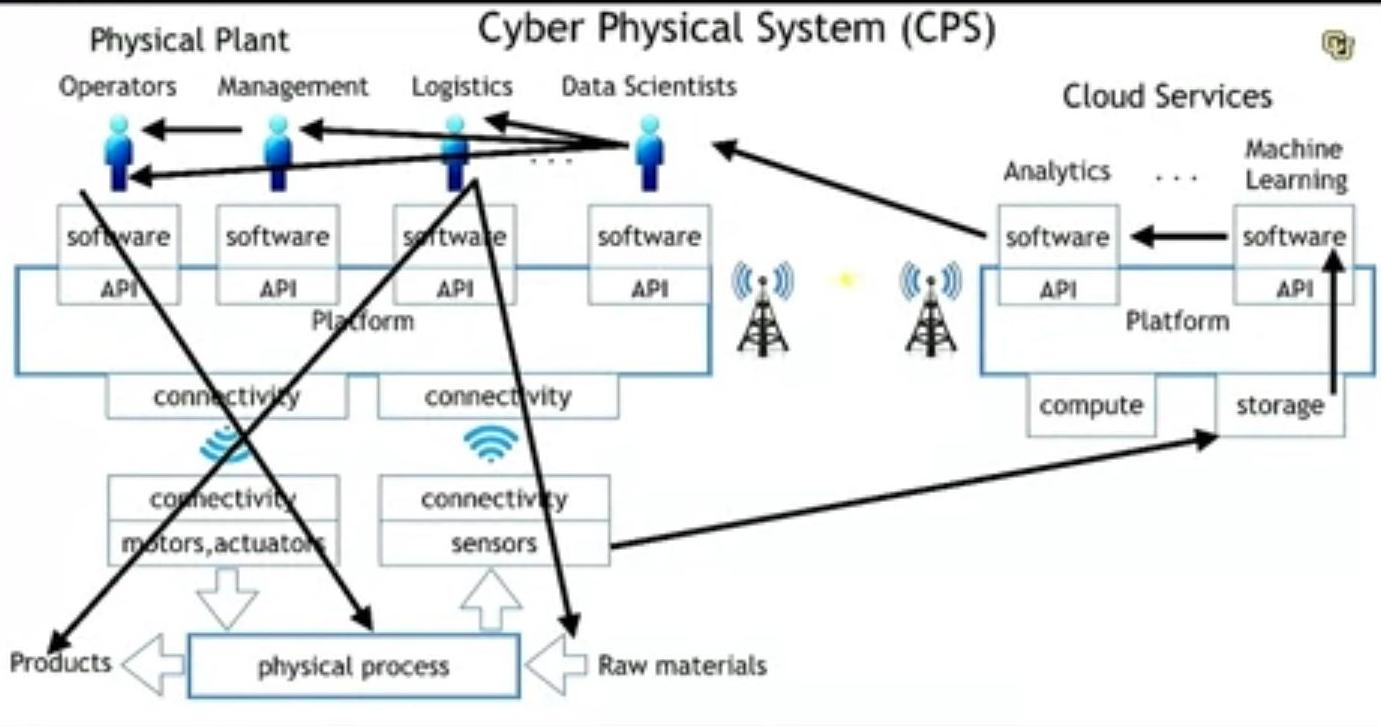
- Platform
 - Allow central monitoring and control of each and every activity that takes place in an organization
 - Highly customizable software and API's that allow external developers to create specialized applications
 - Device management
 - Application management
 - In this context “Application” means Agriculture, Building Automation, Oil & Gas etc. - the business segment
 - Network management
- Purpose: Empowers system admins to monitor, control, visualize, simulate, schedule and analyze all organizational activities from a single location



All this capability within the platform empowers system administrators to



So here we have on the left side
of this cyber physical system,



The platform is the glue that pulls all of this together and

Market Coverage

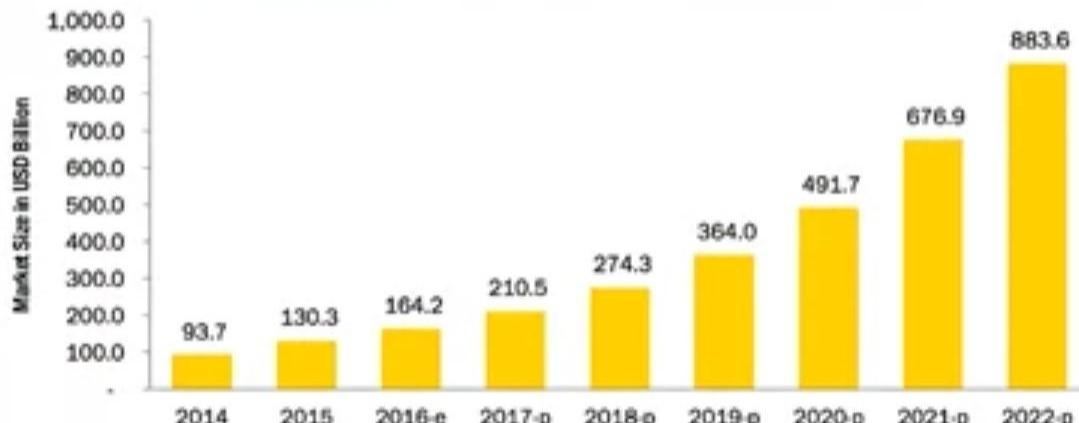
- Hardware
- Platforms, Software, Services
- Applications:
 - Agriculture
 - Building automation
 - Manufacturing
 - Automotive & Transportation
 - Oil & Gas
 - Energy



transportation, and oil and gas, and the energy sector.

High Growth Ahead

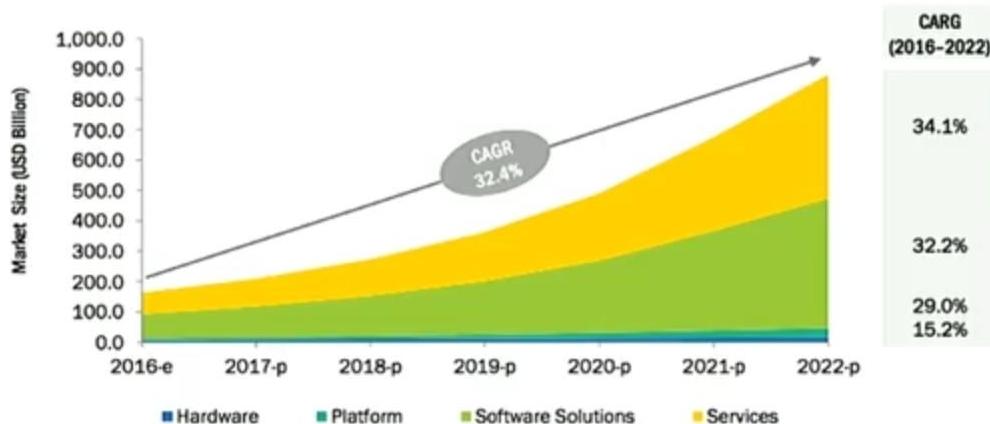
FIGURE 6 IOT TECHNOLOGY MARKET TO CROSS USD 880 BILLION BY 2022



My personal opinion is always
going to be outsourced.

4.2 IOT TECHNOLOGY MARKET, BY APPLICATION(2016–2022)

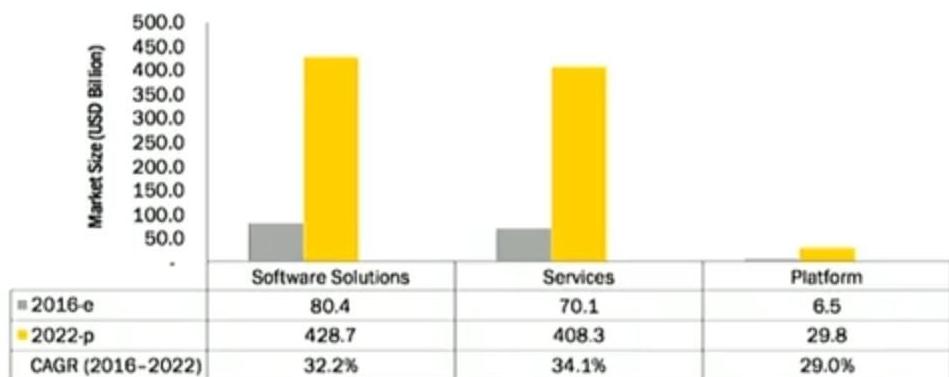
FIGURE 13 IOT SOFTWARE SOLUTIONS TO HOLD THE LARGEST MARKET DURING THE FORECAST PERIOD



and I'm not sure why they split out.

Software

FIGURE 8 SOFTWARE SOLUTIONS TO HOLD THE LARGEST SHARE OF THE IOT TECHNOLOGY MARKET



That was 2015, and this was the amount in 2022, and it doesn't seem

Software Market Breakdown

- Real-time streaming analytics
- Network bandwidth management
- Remote monitoring
- Security
- Data management (big data - how to store and analyze)



all the planetary capacity
to manufacture flash,

4.5 IOT TECHNOLOGY SOFTWARE SOLUTIONS MARKET, BY TYPE (2016-2022)

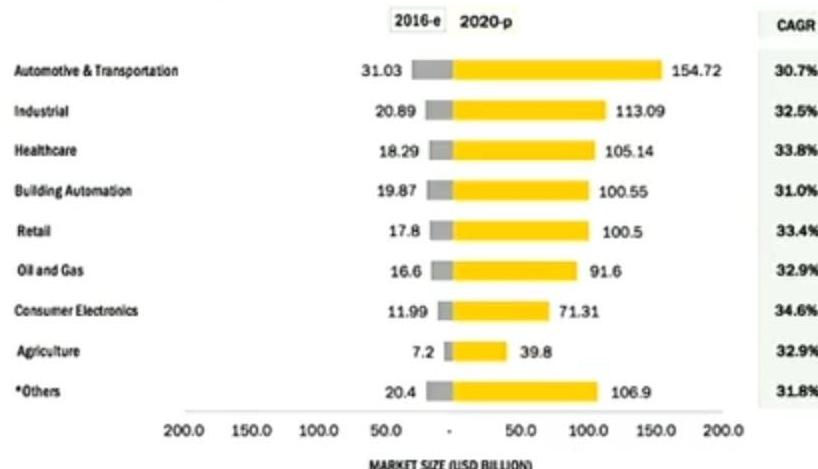
FIGURE 16 NETWORK BANDWIDTH MANAGEMENT SEGMENT TO DOMINATE THE SOFTWARE SOLUTIONS MARKET DURING THE FORECAST PERIOD



So they claim
Network Bandwidth Management Segment is

Automotive & Transportation

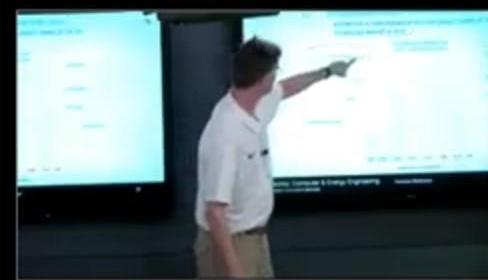
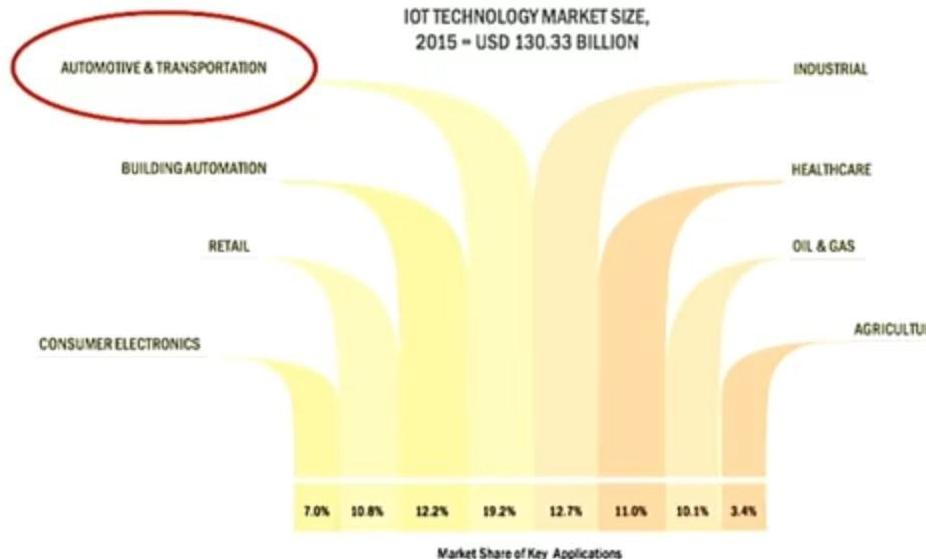
FIGURE 9 AUTOMOTIVE & TRANSPORTATION APPLICATION TO DOMINATE THE IOT TECHNOLOGY MARKET DURING THE FORECAST PERIOD



This one's a key slide,
I've stared at this often.

4.3 IOT TECHNOLOGY MARKET: KEY APPLICATIONS, 2015

FIGURE 14 AUTOMOTIVE & TRANSPORTATION HELD THE LARGEST SHARE OF THE IOT TECHNOLOGY MARKET IN 2015



This is real data from 2015 and you'll see the automotive and transportation segment

Partnerships

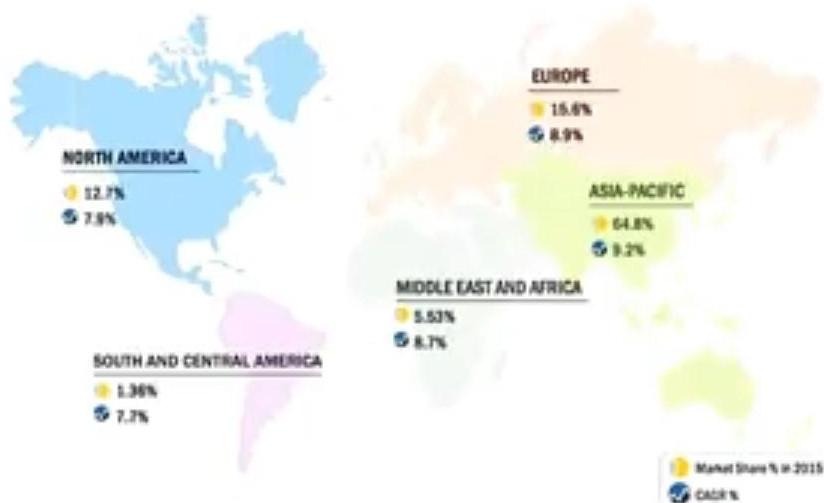
- “Strategies such as agreements, collaborations, joint ventures, and partnerships collectively accounted for 36% of the total strategic developments. This strategy was adopted by all major players in the market (2015-2016) as companies look beyond their core strengths to grow at a rapid rate in the IoT technology market.”
- What’s the trouble with partnerships?
 - Partners can become “Frienemies”, and later outright competitors



[LAUGH]
I have lived

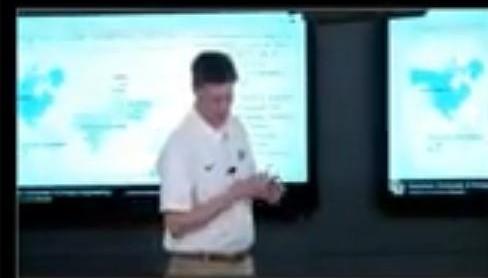
Geographical Market Share

FIGURE 10 ASIA PACIFIC HELD THE LARGEST MARKET SHARE, 2015



"The Asia-Pacific region is expected to grow at the highest CAGR of 38.3% from 2016 to 2022, followed by the Middle East & Africa"

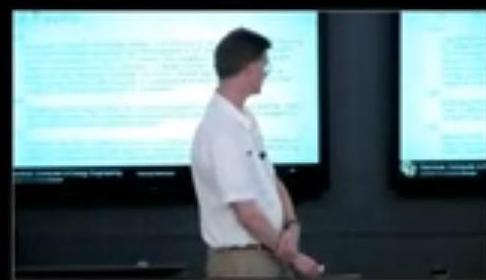
"In China, there is a great deal of enthusiasm for Internet of Things, mainly owing to the heavy financial and strategic involvement of the government in IoT-based developments"



Here's a geographical market breakdown.

Top Players

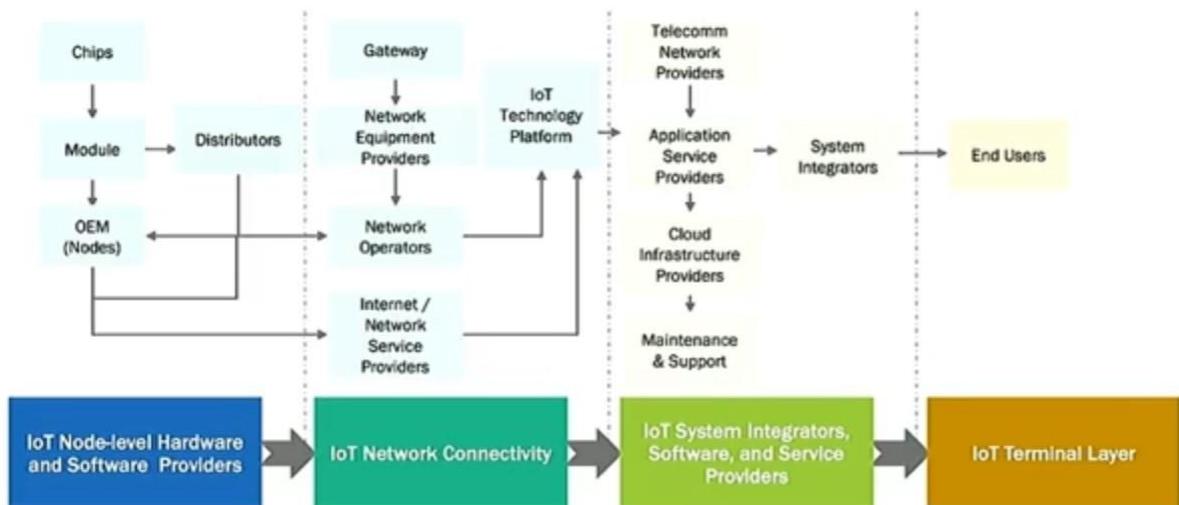
- Intel
 - Top player in the IoT technology market. It is involved in the design and manufacturing of integrated digital technology and development of IoT platforms which are helpful for the development of overall IoT market. The company's Internet of Things group segment offers platforms for customers to design products for the retail, transportation, industrial, buildings, and home market segments. The Internet of Things group (IoTG) further focuses on establishing an end-to-end architecture that captures actionable information for consumers
- IBM
 - Ranked second in the market. The company is actively investing on R&D and has more than 7,000 patents. The company collaborated with various IoT players to expand its IoT portfolio and offer innovative solutions
- GE
 - Ranked third. The company is focused on providing analytics platform and solutions to help data prediction through real-time analytics to assist organizations in forecasting better business outcomes and improving their operations.



The company is focused on providing analytics platform and solutions to help

Value Chain

FIGURE 21 VALUE CHAIN ANALYSIS: IOT TECHNOLOGY MARKET

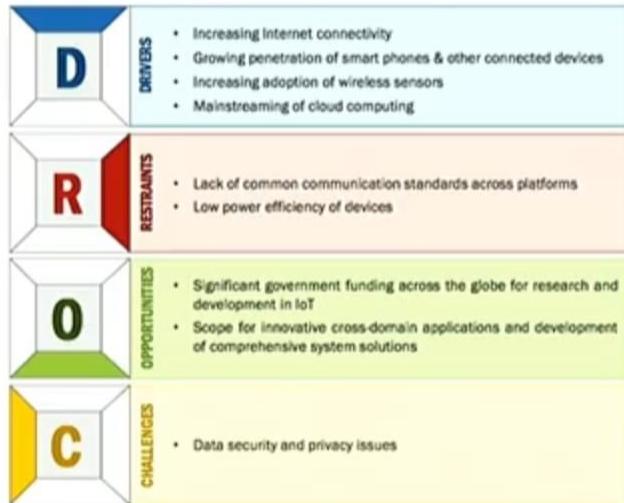


[LAUGH] So don't get too caught up
on the direction of the arrows.

Market Dynamics



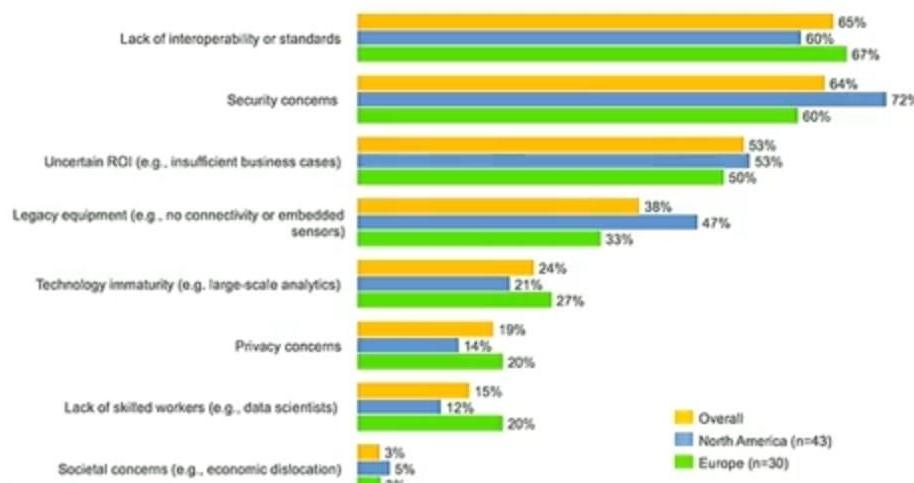
FIGURE 19 INCREASING INTERNET CONNECTIVITY TO ENHANCE THE GROWTH OF IOT TECHNOLOGY MARKET



Market Barriers

Figure 3: Key barriers in adopting the Industrial Internet

Q: What are the greatest barriers inhibiting business from adopting the industrial internet?



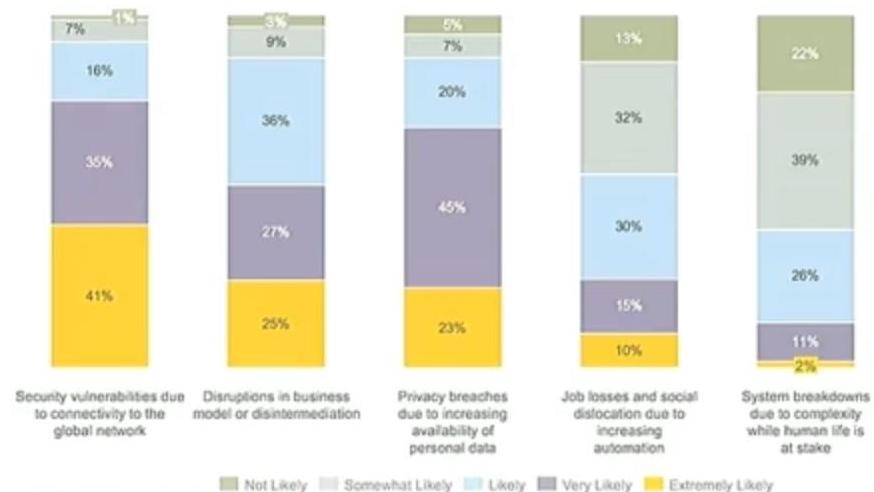
Source: <https://www.rti.com/industries/iot-faq.html>

there's a bunch of interesting
information out there at this site.

Market Risks

Figure 4: Likely risks for adopting the Industrial Internet

Q: How likely are the following risks or negative consequences associated with the Industrial Internet?



Source: <https://www.rti.com/industries/iot-faq.html>

negative consequences associated
with the industrial Internet?

KEY FINDINGS

- IoT is changing the technological landscape across all verticals, and organizations are seeking ways to make improvements amidst the evolution.
- The market is expected to be driven by factors such as increasing Internet connectivity worldwide, increasing demand for the smart phones & other connected devices, increasing adoption of wireless sensors, and mainstreaming of cloud computing.
- Lack of common communication standards across platforms and low power efficiency of devices act as restraining factors for the growth of the market.
- Significant government funding across the globe for research and development in IoT presents a new growth opportunity for players in the market.
- Overcoming data security and privacy issues is important for the growth of the IoT technology market.



Source: Markets and Markets

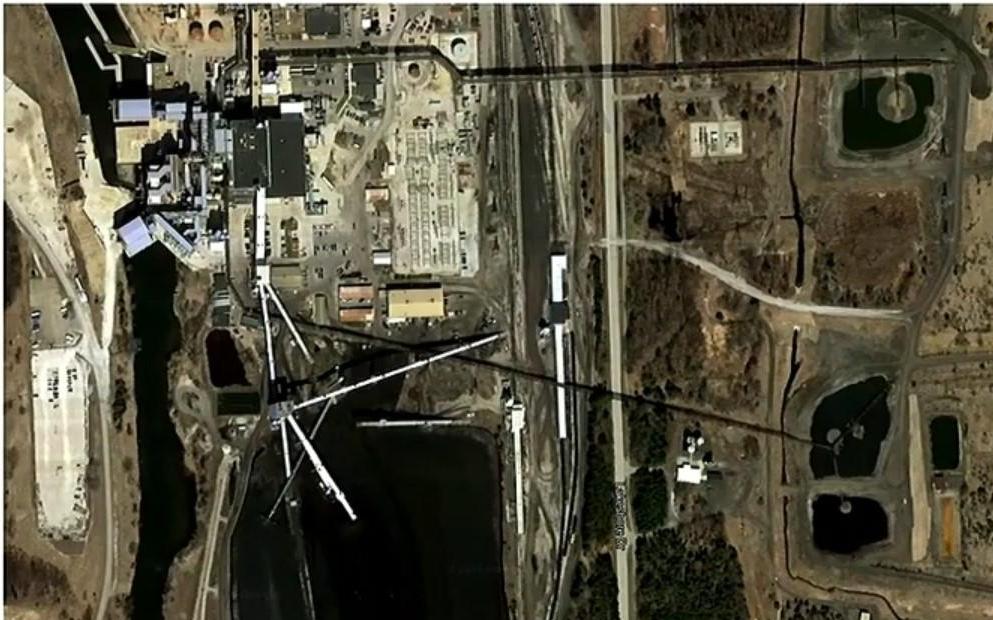
That means all those application segments that were mentioned earlier.

Case study: Consumers Energy Co. JH Campbell Plant, Michigan



and I got a summer job there one summer,

Case study: Consumers Energy Co.



six stories down below the surface.

Case study: Consumers Energy Co.

- Unit 3: (~830 MW), has over 15,000 "hard" I/O points (4,346 analog, 10,940 digital)
- The site (operations, engineering, maintenance) constantly reviews trend data, alarms, point excursions etc. to diagnose past failures and anticipate future failures.



Source: John Hiddema, PE, Consumers Energy Co.

to diagnose past failures and to anticipate future failures.

Case study: Coal Pulverizers



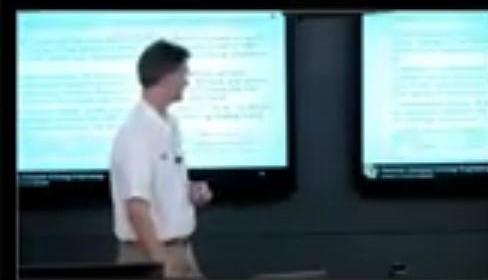
- https://www.youtube.com/watch?v=k_lG-tXihIU

they're lumps like the size of a softball,

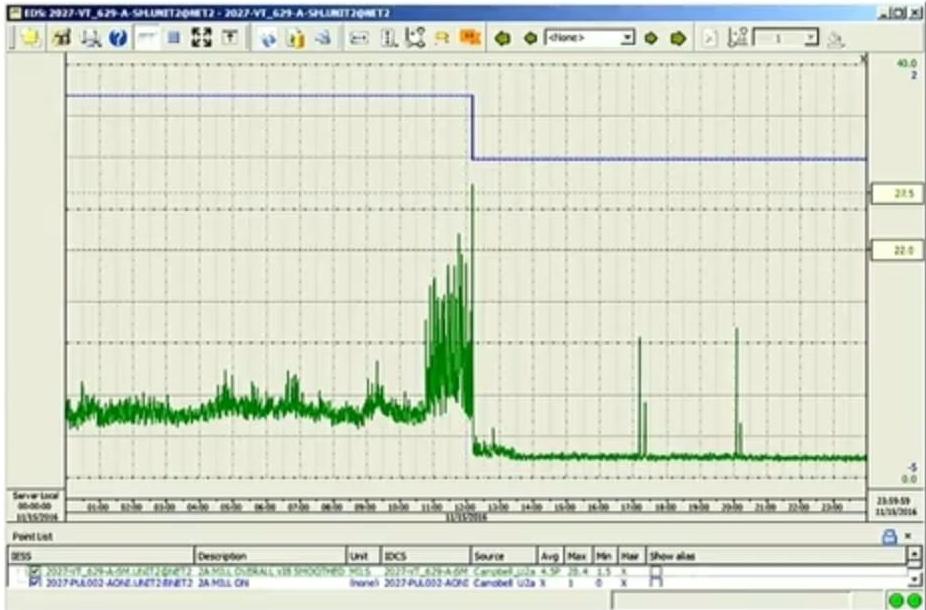
Case study: Coal Pulverizer main shaft vibration

- Has had issues with the main shaft breaking on Unit 2 mills (due to various issues: change of fuel blend on the unit from 100% Eastern Coal to 100% Western Coal, tramp iron, running the mill “lean” during startup/shutdown etc.)
- In attempt to remove the mill from service prior to failure, we have installed overall vibration probes on the mill housing. We have also setup alarm limits and an Alarm Response Procedure (ARP) to remove the mill from service if the overall vibration is above a prescribed limit.
- In the example below, 2A Mill went above 27.5 mils on 11/15 at ~12:00 and the operators removed the mill from service. We ended up finding tramp iron (foreign metal from the mine) in the mill.
- The ARP directs the operator to the trend and locally monitor the mill if in High Alarm Limit 1, remove the mill from service if in High Alarm Limit 2 for 2 minutes. The alarm has to go below 14 mils for 32 seconds to reset.

Source: John Hiddema, PE, Consumers Energy Co.



Case study: Coal Pulverizer housing vibration



So you can see the vibrations here,

Case study: Coal pulverizer main shaft vibration 

Mill Alarm Limits	
Normal Operating	4.0 – 11.0 mils
High Alarm Limit 1	22.0 mils
High Alarm Limit 2	27.5 mils
Reset	< 14 mils (32 seconds)



Source: John Hiddema, PE, Consumers Energy Co.

So it's just a table of what their normal operating range was was four to 11 mils.

Key Skills to Develop

- Manager at Accenture:
 - Network Security/ Security Infrastructure/ Data Security: This has always been on the top of the list, however after recent incidents, this has become an even more important skill that employers are looking for in people. The data is stored in cloud and cloud security is what they are focusing on currently.
 - There are also certain programmers who are trying to make patterns out of the sensor data outputs -> Data Analytics
 - Software Programming: C/C++/Python/Java/Node.js/Javascript/RubyonRails are the major programming languages that they test candidates on depending on the requirement. They look for everything in a candidate including data structures and algorithms.



Software and programming, they sought from their perspective,

Key Skills to Develop

- Senior Engineer at Arrow deploying IIoT:
 - Wireless communications. Know the Pros/Cons of each.
 - Sensing systems
 - Sensor types
 - Calibration
 - Digital filtering methods
 - Embedded processing platforms
 - OS/RTOS
 - Cloud platforms and services
 - Security



He works with big customers and smaller customers to help them build these systems.