

Developing the Industrial Internet of Things

1

Instructor: Dave Sluiter

Learning Outcomes

- Understanding platforms, software solutions and services
- Understanding the market potential for platforms, software solutions and services



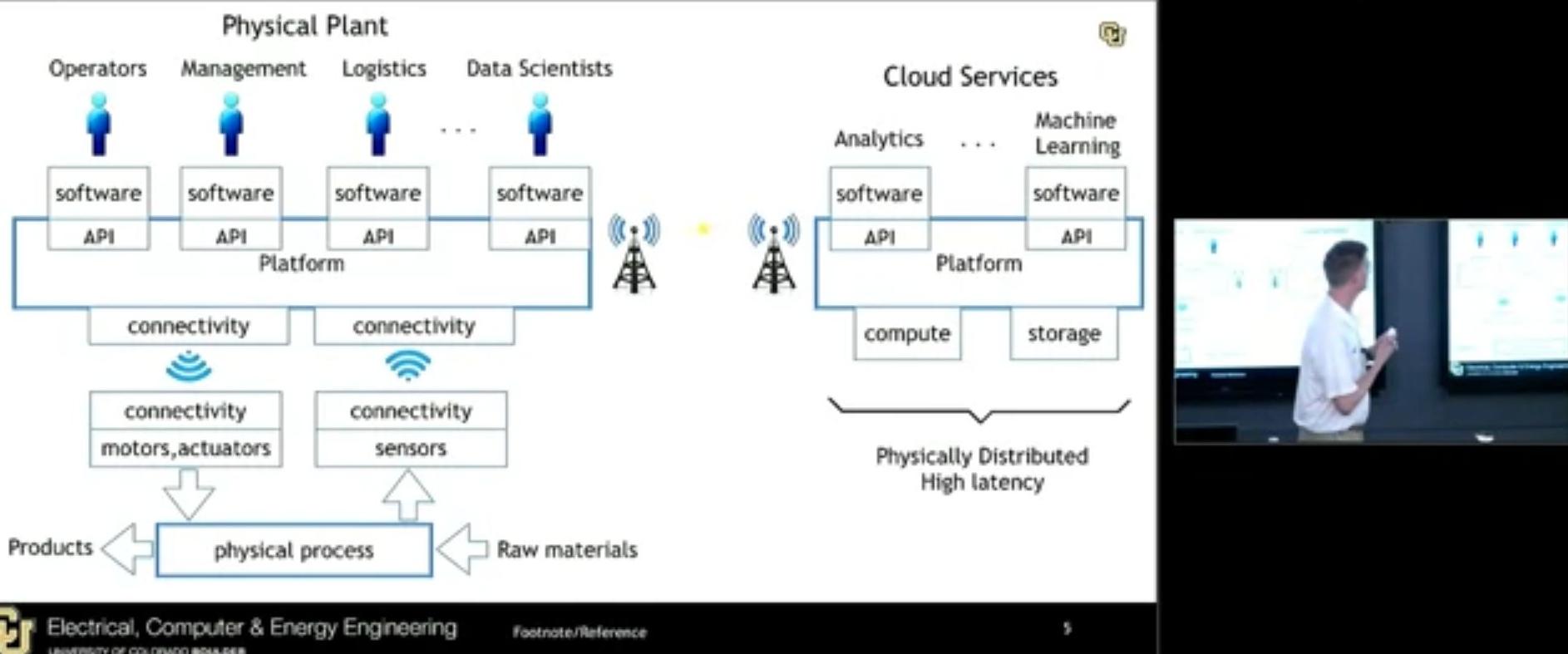
for these platform software solutions and services.

Material

- Platforms
- Software Solutions
- Services



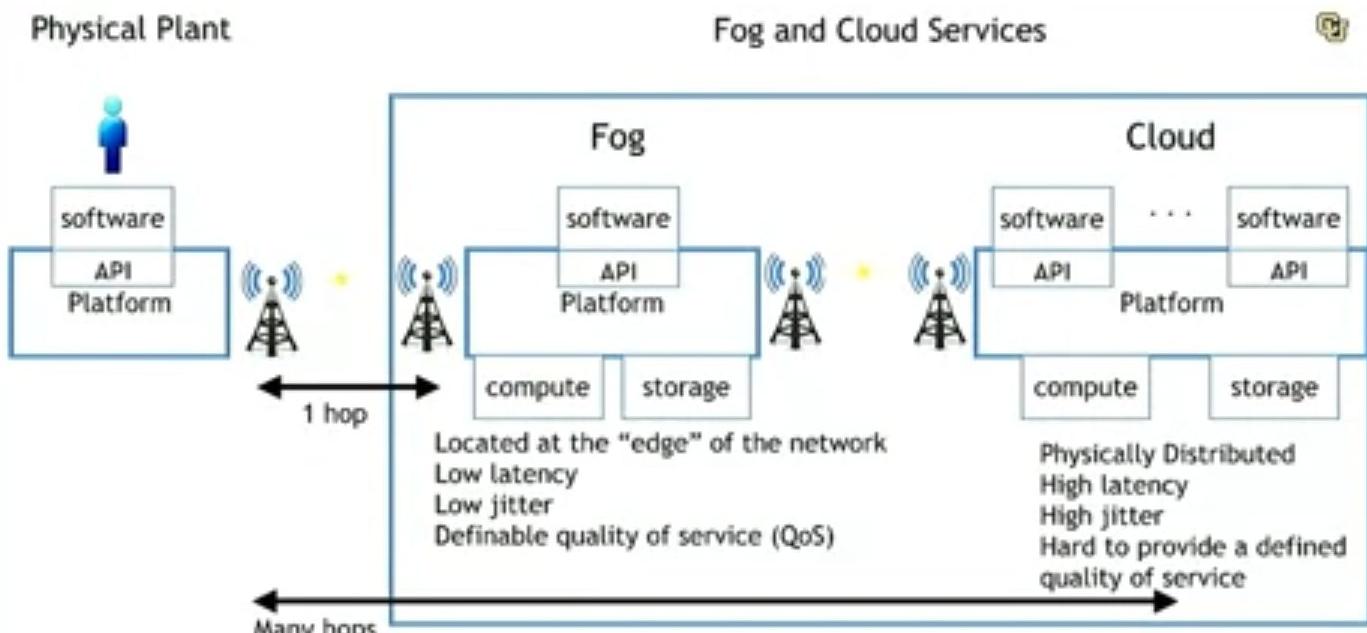
Material as, if I mentioned.



This is the picture I drew in the slide deck for last week,

Physical Plant

Fog and Cloud Services



Who's heard of the term edge computing or fog computing?

Platforms

- Apple HomeKit (consumer)
- <https://developer.apple.com/reference/homekit>



Platforms

- IoTivity
- The IoTivity is an open source project. The IoTivity project is hosted by the Linux Foundation, and sponsored by the OIC that is a group of technology companies such as **Samsung Electronics** and **Intel** who will be developing a standard specification and certification program to enable the Internet of Things. Includes AllJoyn now.
- <https://api-docs.iotivity.org/latest/index.html>
- <http://www.intel.com/content/www/us/en/internet-of-things/white-papers/iot-platform-reference-architecture-paper.html?wapkw=iot+platform>
- OIC ([Open Interconnect Consortium](#)), Samsung, Atmel, Broadcom, Dell, Intel and Wind River





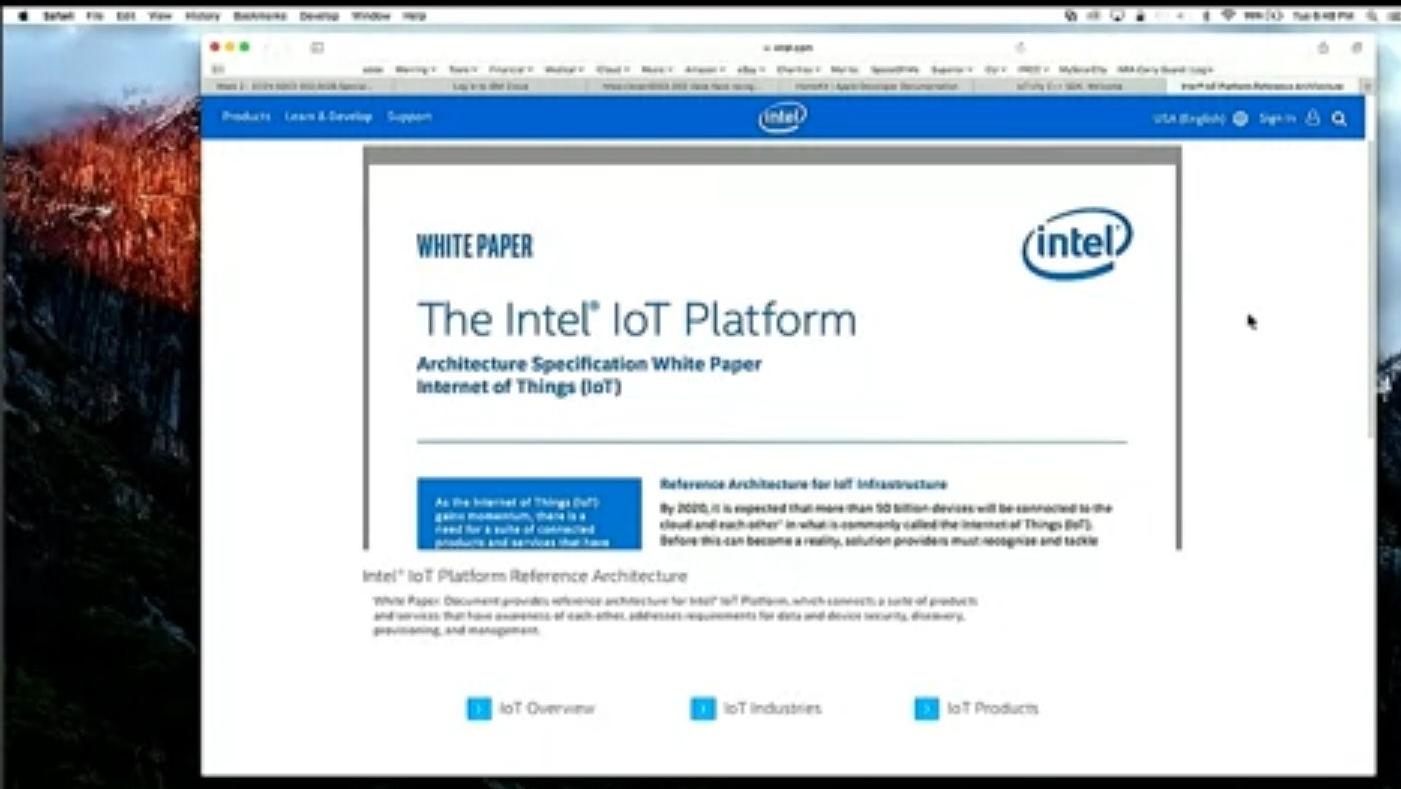
The screenshot shows a web browser window displaying the IoTivity C++ SDK API Reference. The title bar reads "IoTivity C++ SDK". The main content area is titled "Welcome" and contains the following text:
IoTivity is an open source software framework enabling seamless device-to-device connectivity to address the emerging needs of the Internet of Things. These API references are for any developer trying to utilize the IoTivity project for building applications.

The left sidebar has a tree view of the API Reference:

- IoTivity C++ SDK
 - Welcome
- API Reference
 - Class List
 - OC
 - OIC
 - _mTopic
 - NSConsumer
 - NSConsumerConfig
 - NSMediaContents
 - NSMessage
 - NSProvider
 - NSProviderConfig
 - NSSyncInfo
 - OCByteString



API reference, list of all the classes,



The screenshot shows a web browser window displaying an Intel IoT Platform white paper. The page has a blue header with the Intel logo and navigation links for Products, Learn & Develop, Support, USA English, Sign In, and a search bar. The main content area features a large image of a forest at sunset. The title "WHITE PAPER" is in bold capital letters, followed by "The Intel® IoT Platform". Below the title is a subtitle "Architecture Specification White Paper" and a specific section "Internet of Things (IoT)". A callout box on the left says "As the Internet of Things (IoT) grows immensely, there is a need for a suite of interconnected products and services that have...". Another callout box on the right says "Reference Architecture for IoT Infrastructure". At the bottom, there's a section titled "Intel® IoT Platform Reference Architecture" with a brief description and a link. At the very bottom, there are three navigation links: "IoT Overview", "IoT Industries", and "IoT Products".



the companies have moved around some of their material but they'll get it close.

Platforms

- IBM Watson
- [http://www.ibm.com/internet-of-things/iot-solutions/
watson-iot-platform/](http://www.ibm.com/internet-of-things/iot-solutions/watson-iot-platform/)





last week when I talked about power plant where I worked at,



The screenshot shows a web browser window with multiple tabs open. The active tab displays the Cisco Jasper Control Center website. The page features a dark blue header with the Cisco Jasper logo and navigation links for Customers, Products, Retail IoT, About Us, Partners, and Resources. Below the header, a large banner with a computer monitor background and teal accents displays the headline "Manage connectivity of all your IoT devices". A subtext explains: "Ensure your devices connect reliably, securely, and cost-efficiently with Control Center, the IoT platform that automates connectivity management". A "Learn more about Control Center" button is present. At the bottom, three circular icons represent "IoT Devices" (building), "Business Mobile Phones & Tablets" (phones), and "Connected Cars" (car). The browser's address bar shows a complex URL related to the Control Center.



happens to be the name of my dog.



The screenshot shows a web browser window with a dark-themed user interface. The main content area displays a video player showing a man in a dark t-shirt and cap looking at his phone. The video has a caption: "Neura's AI-fueled User Awareness Responds to Real-time Moments". Below the video, text reads: "Neura is an AI Engine that allows your product to:". Three icons are listed: "Engage at a Perfect Moment" (person icon), "Anticipate User's Needs" (chart icon), and "Adapt to Each User" (person icon). A vertical sidebar on the left contains various navigation links and search results.



I just included it and again there's documentation examples.

Platform Market

- The market for platforms is expected to grow at a CAGR of 29.0% between 2016 and 2022 to reach USD 29.83 billion by 2022.
- Further categorized into:
 - Device management
 - Application management
 - Network management



Platforms is expected to grow
by almost 30% between 2016 and

Device Management

- “The device management platform assists organizations in managing, tracking, securing, and sustaining the abundant devices that are used in the organization. It also helps in managing devices’ content, configuration as well as assists in policy and compliance management.”



Application Management

- “Connected devices generate huge amount of sensor data. Traditionally, this sensor data was sent to the applications that stored and managed it securely. However, the developers faced a tedious task to create applications based on a “home grown” application framework.



However, the developers faced a tedious task to create applications based on

Application Management

- “Connected devices generate huge amount of sensor data. Traditionally, this sensor data was sent to the applications that stored and managed it securely. However, the developers faced a tedious task to create applications based on a “home grown” application framework.
- The **application management platform** addresses the mentioned issues by connecting the devices over a network and assists in designing, developing, and managing applications. The application management platform offers various features such as application hosting, remote device management, data storage, monitoring, sharing, and management and analytics capabilities. The **application management platform API** is an important component. It provides access management, gateways, data communication and coordination, fault tolerance and security.”



previously mentioned issues by connecting
the devices over a network and

Network Management

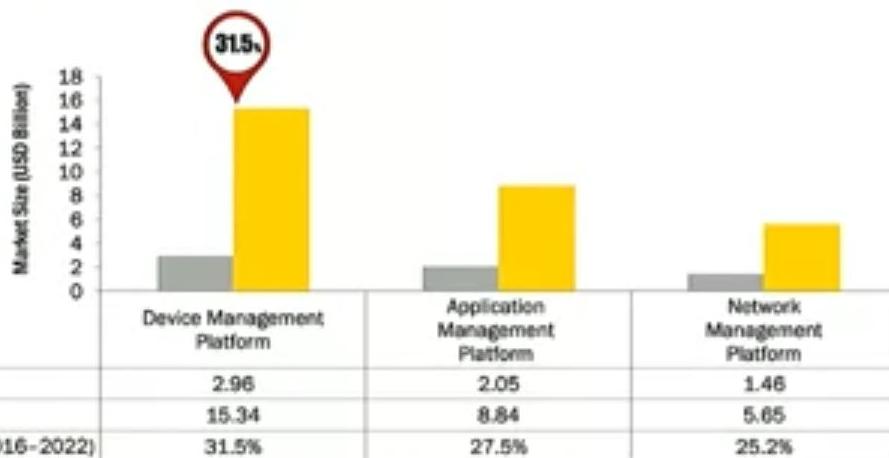
- “Network management platform provides a common platform to manage the entire network of an organization. The platform ensures that the users are able to receive IT services from anywhere and at any time. By using the platform, a network administrator can easily detect any failure in the network and resolve issues in realtime or by informing the support personnel.”
- “The network management platform also assists in analyzing the amount of data transferring over a network and automatically routes them, to avoid congestion that can result in a crash of the network. For critical applications areas, such as mobility and transport, logistics, energy, and manufacturing, seamless and faster data transfer is required. This requires appropriate configuration of network devices and is possible only through a high level of visibility provided by the network management platform.”



So network management platform also
assists in analyzing the amount of data

Platform Market

FIGURE 33 DEVICE MANAGEMENT PLATFORM EXPECTED TO LEAD THE IOT TECHNOLOGY MARKET DURING THE FORECAST PERIOD



An example deployment

- Building automation for a 5-story building



you how all the data can
add up pretty quickly.

An example deployment (con't)

- 5 floors
- 2 units per floor = 10 units
- 20 people/unit = 200 people/building
- 2 entrances



An example deployment (con't)

Sensor/Actuator	Protocol	# Needed
Occupancy	EnOcean	$200 + 60 \text{ hall/stairs/elev} = 260$
Daylight	WHART	4
Thermostat	Z-Wave	$4 \text{ zones/unit} * 10 \text{ units} = 40$
Camera	WIFI	$4 \text{ cam/unit} * 10 \text{ units} + 6 \text{ outside} = 46$
Power meter	ANT	$10 \text{ units} = 10$
Locks	Zigbee	$10 + 2 \text{ exterior} = 12$
Smoke/Gas detector	WHART	$8/\text{unit} * 10 \text{ units} + 60 \text{ hall/stairs/elev} = 140$
Lighting control	EnOcean	$10/\text{unit} * 10 \text{ units} + 60 \text{ hall/stairs/elev} = 160$
	total = 6	total = 672



An example deployment (con't)





An example deployment (con't)

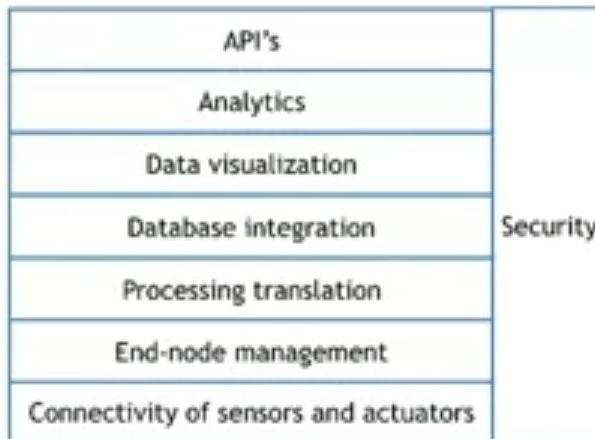
- How do we connect all of this together?
- How do we manage all of these devices?



All right, so we need them,
how do we connect all of this together?

An example deployment (con't)

- Platform to the rescue



Source: Industry 4.0, Alasdair Gilchrist

Well, the answer is a platform.

An example deployment (con't)

- Connectivity: This layer provides the means to connect and support the sensors and actuators, supporting all the protocols
- End-node management: This layer provides the ability to identify, authenticate, authorize and manage end-nodes
- Data processing: This layer provides data translation and preparation for the data coming from sensors
- Database integration: This layer provides the connection between applications (software) and data storage
- Data visualization: This layer provides the tools/techniques to visualize the data in meaningful ways; charts, graphs etc
- Analytics: This layer can provide the processing for feedback, either realtime, or delayed.
- APIs: This layer provides the APIs and the software development kit (SDK) for programmers
- Security: Integrated into every layer to ensure confidentiality, integrity and availability



And security, again,
has to be thought about and

Software Market Breakdown

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



how to store and analyze.

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



We'll see examples later in the semester.

Real-time streaming analytics

- “Organizations worldwide are focusing towards the use of advanced IT systems to overcome the challenges faced by them in day-to-day operations. Huge data volumes are generated through various smart and connected devices which are used for various applications across different industry verticals.
- This data could be transformed into crucial information and insights with the help of data analytics to yield greater efficiency, productivity, and profitability to the organizations.
- Advanced solutions such as real-time streaming analytics have transformed conventional management into fact-based, decision-driven management.”



Real-time streaming analytics (con't)

- “Moreover, it also helps to detect anomalies in real-time data and trigger alert when there is an error. This can assist organizations for easy decision-making, customer retention, and taking appropriate business related decisions in realtime.
- Therefore, understanding the increasing importance of this technology, companies such as Microsoft Corporation, SAP SE, Amazon Web Services, and IBM Corporation have developed realtime analytics solution for IoT. Large investments in cloud-based solutions and high internet penetration are the factors propelling the growth of the market.”

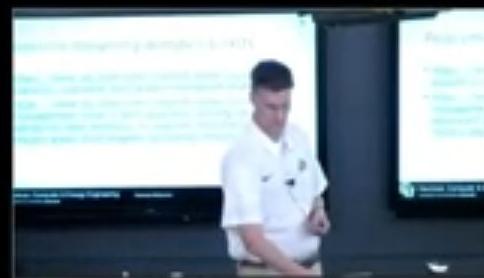


So, understanding the increasing importance of this technology,



Real-time streaming analytics (con't)

- <https://www-ssl.intel.com/content/www/us/en/analytics/overview.html?wapkw=advanced+analytics>
- <https://www-ssl.intel.com/content/www/us/en/it-management/intel-it-best-practices/joining-iot-with-advanced-data-analytics-to-improve-manufacturing-results-paper.html?wapkw=advanced+analytics>



this market segment. Jump out here.



The screenshot shows a web browser window displaying the Intel Advanced Analytics homepage. The main banner features a blue background with a network of glowing blue squares and the text "BUILD AN INSIGHTS-DRIVEN BUSINESS". Below the banner, a sub-section titled "Getting Started with Advanced Analytics" includes a call-to-action button labeled "Learn More". On the left side of the page, there is a sidebar with various analytical tools and services listed under categories like "Software", "Machine Learning", "Real-time streaming", and "Predictive modeling". The top navigation bar includes links for "Product", "Solutions", and "Support". The URL in the address bar is "http://www.intel.com/advanced-analytics".



This takes you out to Intel's insight driven business,



The screenshot shows a web browser window with the URL www.intel.com/iot-data-analytics-manufacturing. The page title is "IoT Plus Advanced Data Analytics Improve Manufacturing Results". The main content features the Intel logo and the text "IT@Intel Joining IoT with Advanced Data Analytics to Improve Manufacturing Results". Below this, there is a section titled "IoT Plus Advanced Data Analytics Improve Manufacturing Results" with a brief description and a "Show more" link.



I will tell you about their data analytics for IoT.



The screenshot shows a Microsoft Word document window. The title bar reads "Smart Lecture Notes - Day 1". The main content area contains a slide with the following text:

Security

- "The diversified reach of IoT has led to the evolution of several threats such as malware and bots, which can cause huge losses in financial and personal data. These threats could have a devastating impact on smart grid and smart transportation where a single cyber-attack could prove fatal for businesses and can lead to great financial loss. IoT security solutions include application security, device security, and network security solutions."
- "Companies such as Cisco Systems and Symantec Corporation are developing security solutions that enable organizations to secure their IoT ecosystem."

At the bottom left of the slide, there is a logo for "Electrical, Computer & Energy Engineering" with the text "UNIVERSITY OF COLORADO BOULDER".



So, important things.



Security (con't)

- <http://www.cisco.com/c/en/us/solutions/internet-of-things/iot-security.html>
- <https://aws.amazon.com/security/>
-

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The screenshot shows a web browser window with the Cisco website open. The main header includes links for Home, Webex, Collaboration, Financial, Medical, Cloud, Manufacturing, Amazon, Oracle, Network, Security, Data, PRISM, MyCloud, and Miscellaneous. A sidebar on the left contains sections for Remote Monitoring, Security, Security Events, Data Management, and Remote Monitoring. The main content area features a large image of an industrial facility with pipes and structures, overlaid with the text "IoT Security" and "Cisco IoT Threat Defense strengthens your security architecture and services to defend your IoT deployments." Below this is a blue button labeled "Watch video". At the bottom of the page, there are links for Benefits, Products, Services, and For Partners.



You can go out and read about there,



The screenshot shows the AWS Cloud Security homepage. At the top, there's a navigation bar with links like Home, Contact Sales, Products, Services, Pricing, Getting Started, Documentation, Software, Help, and a sign-in button for AWS Accounts. Below the navigation is a large blue header with the AWS logo and the text "AWS Cloud Security". A sub-header below it says "Protect your data with cloud-powered security." and a call-to-action button "Get the information about security in the Cloud". The main content area has sections for Cloud Security, Automation Testing, Security Bulletins, Resources, Compliance, and Partners. On the left, there's a sidebar with various service icons and names: Security (Security Hub), Data Management (Amazon S3, Amazon Lambda, Amazon Kinesis), and Back Management (Amazon RDS, Amazon VPC). A testimonial from Richard Crowley, Director of Governance, is displayed, stating: "The fact that we can rely on the AWS security posture to boost our own security is really important for our business. AWS does a much better job at security than we could ever do running a data center." Below the testimonial is a Slack logo and a link to "Follow us on Twitter!".



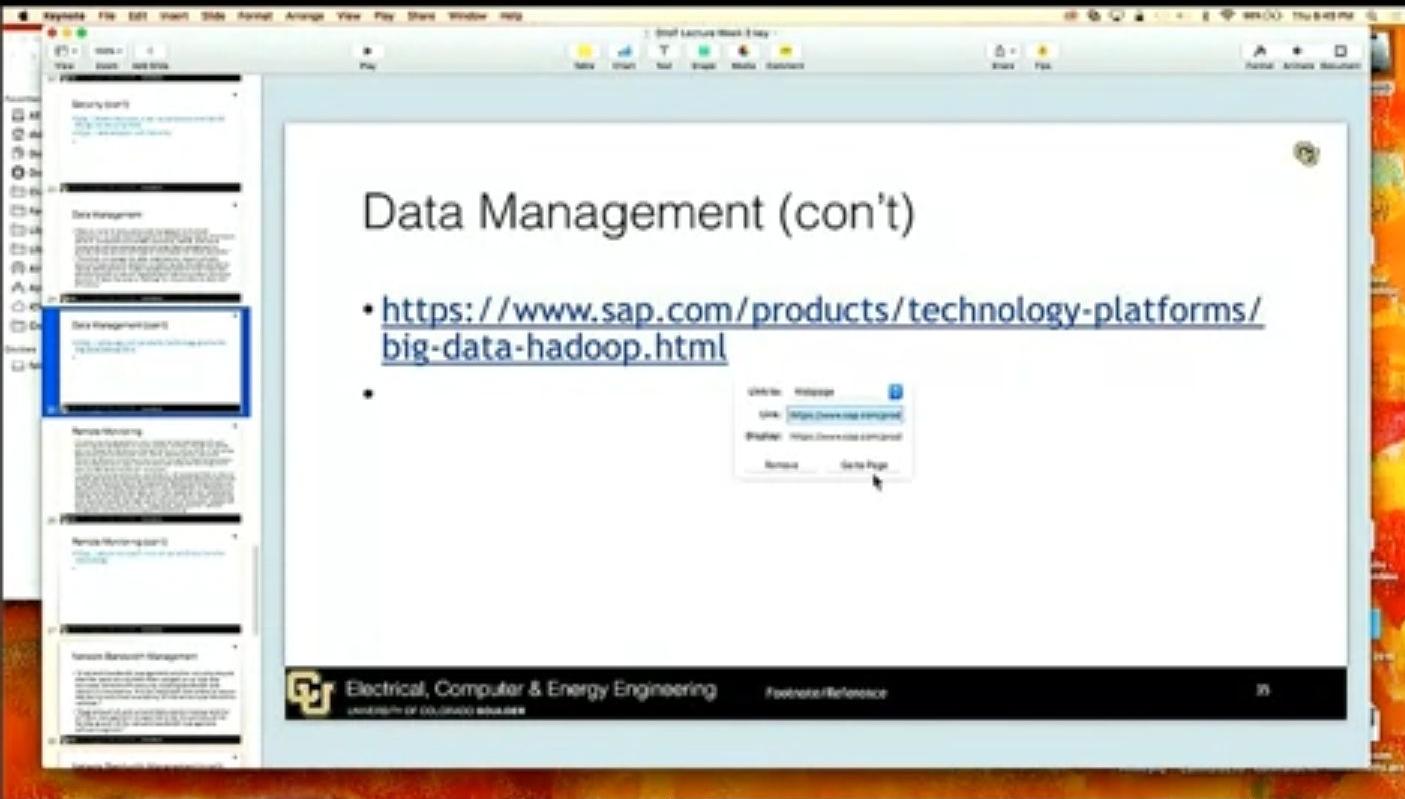


The screenshot shows a Microsoft Word document window. The title 'Data Management' is centered at the top. Below the title, there is a bulleted list of text. At the bottom of the slide, there is a footer bar with the CU Boulder logo, the text 'Electrical, Computer & Energy Engineering', 'Faculty Reference', and a page number '34'.

- "Data is crucial in every sector and managing it is of utmost importance, to understand the patterns and develop logical information out of it. Companies such as IBM Corporation, SAP SE, and Oracle Corporation are developing solutions under data management to provide various sectors with ease of information for future decisions."
- "Therefore, to manage this data, organizations require software solutions featured with analytics to easily handle this data and derive various useful patterns. A data management solution is an important software solution in the IoT segment as IoT devices produce enormous amounts of data that pose a challenge for the providers to deal with efficiently."



Data management. This is



Data Management (con't)

- <https://www.sap.com/products/technology-platforms/big-data-hadoop.html>
-

CU Boulder Connect
Data Management
Data Management User ID
Remote Monitoring
Remote Monitoring User ID
Remote Bandwidth Management

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SAP is heavily involved.



The website "accounts.sap.com" requires a secure certificate. This website requires a certificate for verification of identity. Select the certificate to use when you connect to this website, and then click Certificate.

Big Data

Gain more value from Big Data

SAP offers a broad range of Big Data solutions. Experience the ease of fully-managed Big Data in the cloud. Process diverse, raw data efficiently using advanced distributed processing engines. And now, easily manage your diverse data landscape, across data warehouses, data lakes and databases, both on-premise and in the cloud.



We can go on to SAP site. Yes, sure.



The screenshot shows a web browser window with the SAP homepage open. The URL in the address bar is <http://www.sap.com/soa/bigdata.html>. The page features a large banner image of a smiling man in a lab coat. To the left, there's a sidebar with various navigation links under categories like Security, Data Management, and Remote Monitoring. The main content area has a heading "Gain more value from Big Data" followed by a paragraph about SAP's Big Data solutions. Below this is an illustration of three computer monitors displaying different data visualization interfaces. At the bottom, there's a section titled "SAP Data Hub" with a brief description and a bulleted list of features.

Gain more value from Big Data

SAP offers a broad range of Big Data solutions. Experience the ease of fully-managed Big Data in the cloud. Process diverse, raw data efficiently using advanced distributed processing engines. And now, easily manage your diverse data landscape, across data warehouses, data lakes and databases, both on-premise and in the cloud.

SAP Data Hub

Create value across the diverse data landscape with Big Data hub, data sharing, data integration, and data preparation capabilities. With the customer as a cornerstone and proven methodology, enterprise-wide access is within reach.

- On-premises deployment
- Share, locate & data warehouse management
- Connected & security and governance



Gain more value from Big Data.



Remote Monitoring

- "A remote monitoring system is a very reliable facility that enables efficient monitoring and management of various systems, remotely. Through this system, one can change the operations of the devices from a central office. It has various applications such as smart grid, train control, pipeline sensors, and server monitoring. Remote monitoring is not a recent concept for industrial automation; various organizations in many countries have been using this technology for 25 years through hardwired Ethernet connections."
- "A remote monitoring system also contributes to cost saving and helps to improve business operations by minimizing and preventing unplanned downtime and access to real-time situational data in the organization. Remote monitoring systems are also useful for managing remote devices in case of breakdown or maintenance. A remote monitoring system also takes care of field update services, customization methods, security implications, and device selections. Hence, remote monitoring is an important solution that takes care of the entire IoT ecosystem, ranging from device provisioning, remote access, configuration, administration, software management, and device monitoring and troubleshooting."

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Remote monitoring.



The screenshot shows a Microsoft Word document window. The title bar reads "Staff Lecture Week 8 Day 1". The main content area contains the following text:

Remote Monitoring (con't)

- <https://azure.microsoft.com/en-us/solutions/remote-monitoring/>
-

At the bottom of the slide, there is a footer bar with the CU Boulder logo, the text "Electrical, Computer & Energy Engineering", "Footnote/Reference", and a page number "37".





The screenshot shows a Microsoft Azure IoT page. On the left, there's a sidebar with navigation links like 'Data Management', 'Devices', 'Remote Monitoring', and 'Network Monitoring'. The main content area features a large video player with the title 'Internet of Things' and the subtitle 'Create the Internet of Your Thing by connecting your devices, assets, and sensors to collect unstructured data. Improve performance and reduce costs with remote monitoring. Predict equipment failures before they happen with predictive maintenance.' Below the video, several company logos are displayed: SANDVIK, Schneider Electric, Johnson Controls, Rockwell Automation, and Systematic. A quote from Andreas Schenck, CEO of Systematic Elevator, is shown: 'We wanted to go beyond the industry standard of preventive maintenance, to offer predictive and even preemptive maintenance, so we can guarantee a higher uptime percentage on our elevators.' The quote is attributed to 'Andreas Schenck, CEO, Systematic Elevator'. At the bottom, a call-to-action button says 'Find the right IoT solution for your business'.

Their platform is called Azure,





The screenshot shows a Microsoft Word document window. The title 'Network Bandwidth Management' is centered at the top. Below the title, there is a bulleted list of two items. The footer of the document includes the CU Boulder logo and the text 'Electrical, Computer & Energy Engineering' and 'Foothills Reference'.

- "A network bandwidth management solution not only ensures that the users are notified when outages occur, but also increases network efficiency by tracking bandwidth and resource consumption. It is an important instrument to assure the performance and availability of the servers and the entire network."
- "Huge amount of unstructured data and increasing need for IoT data management is expected to be the primary driver for the growth of the network bandwidth management software segment."



Network bandwidth management.



The screenshot shows the SoftPerfect Bandwidth Manager product page on their website. The page has a green header with links for Products, Download, Order, and Support. A sidebar on the left lists various network management tools. The main content area features a large image of a person in a white shirt standing next to a server rack, with a monitor in the background displaying network traffic graphs. The text on the page describes the product as a bandwidth limiter and traffic shaper for Windows, mentioning its ability to manage multiple network interfaces simultaneously. It also highlights key features like centralized configuration, prioritized traffic, and support for IP and MAC addresses.



So, this company is called SoftPerfect and this is



Services Market Breakdown

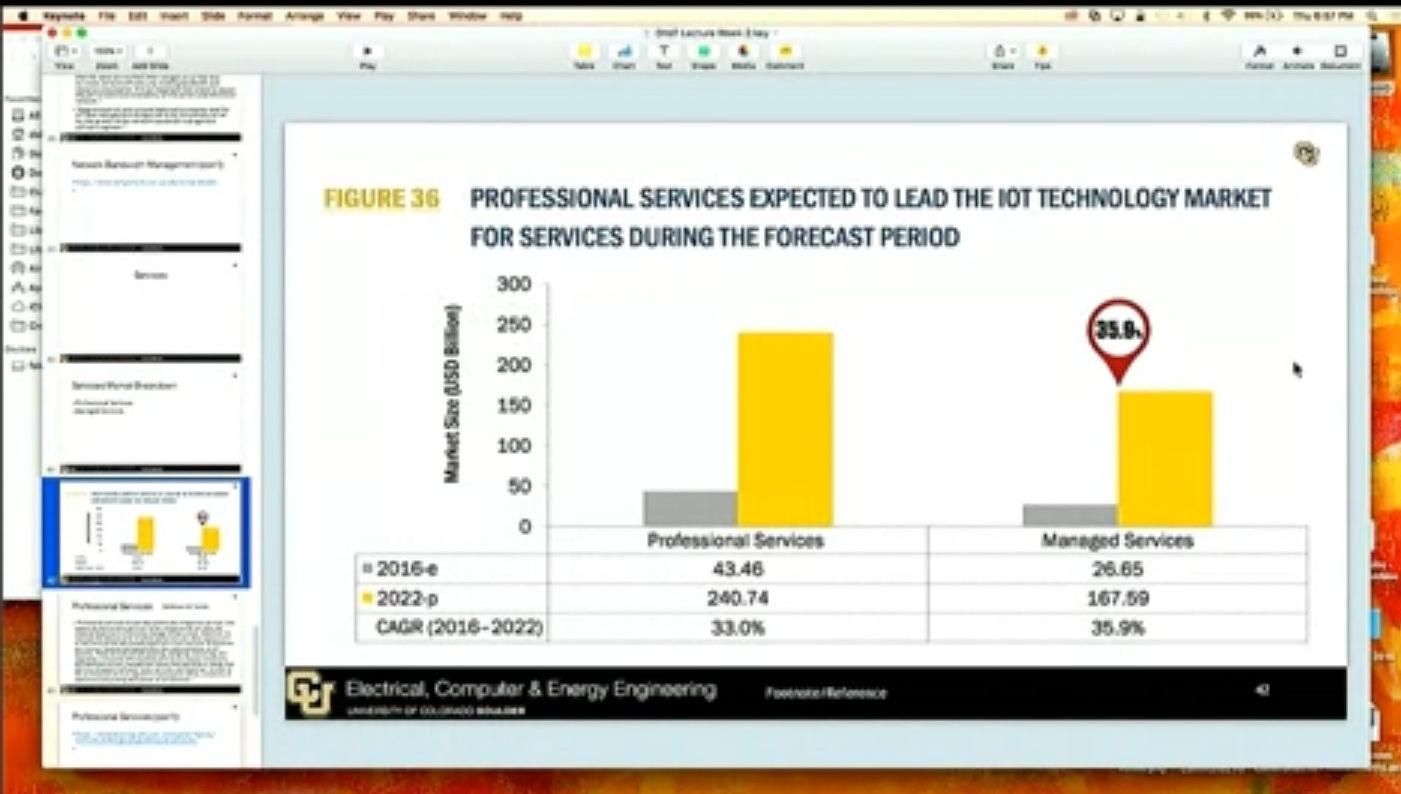
- Professional Services
- Managed Services

CU Boulder Electrical, Computer & Energy Engineering

Footnote Reference



This part of market research report to me is blurry.



So looking at their revenue projections for 2016 versus 2022,



Professional Services Building an IIoT System

- "Professional services include deployment and integration services, and support & maintenance services. Some companies do not have the required expertise to effectively manage infrastructure; therefore, to maintain the desired level of safety and protection, they outsource it to the third parties who possess expertise in such services. Professional services are required during and after the implementation of IoT systems. These services include planning, designing, consulting, and upgrading. Companies offering these services encompass consultants and dedicated project management teams that specialize in design and delivery of support software, tools, services, and expertise. Growth of the professional services segment is mainly governed by complexity of operations and growing deployment of IoT solutions."

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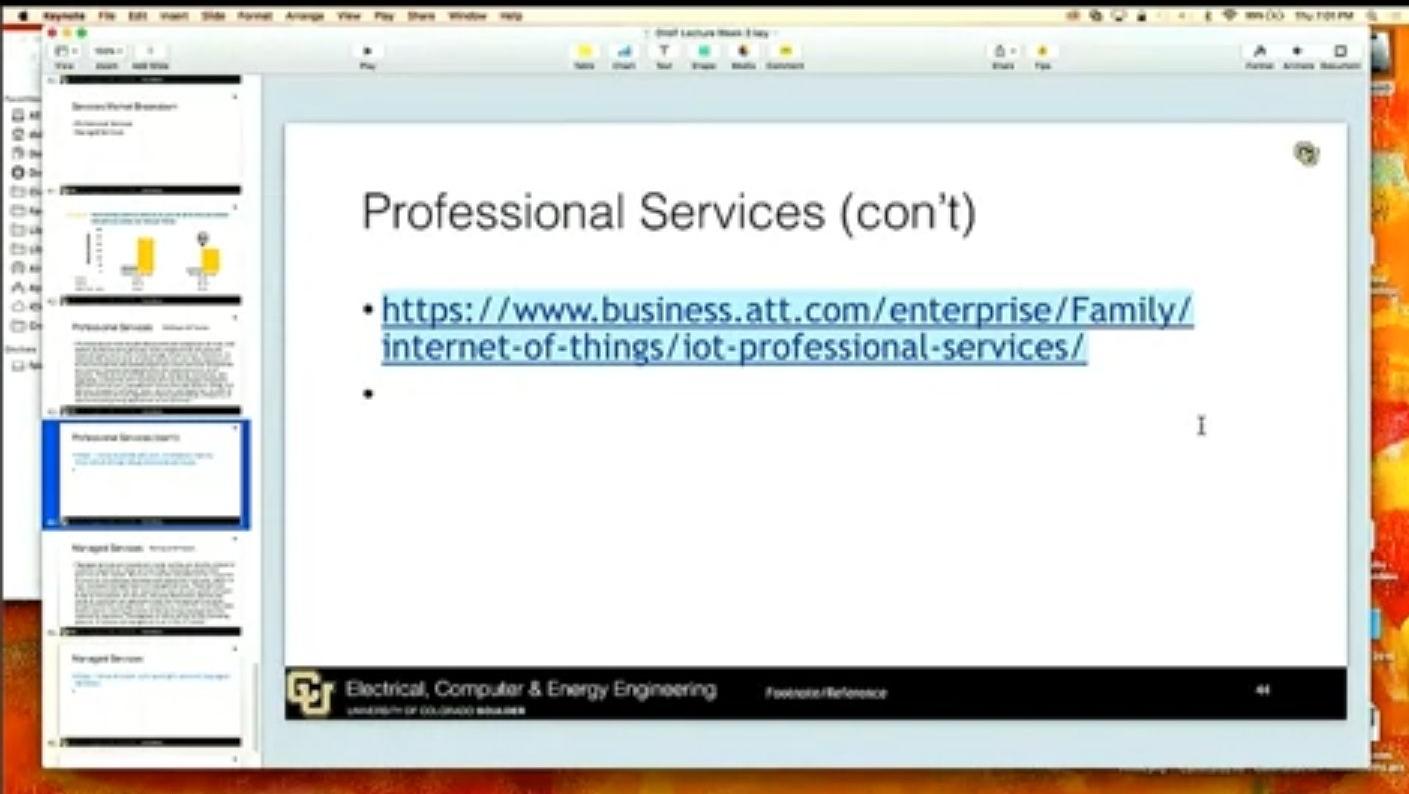


professional services and I came away with this idea that what they were trying



The screenshot shows a web browser window for AT&T Business. The main content area displays a blue header with the text "Professional services for the Internet of Things". Below this, a section titled "Our experts can help you with IoT" is shown, followed by a list of services: "Implement and manage your IoT initiatives", "Design, develop, and optimise device connection software", "Streamline complex device logistics with customized, integrated solutions", "Accelerate innovation and mitigate risks", "Control operational and service costs for your connected environment", and "Expert partner ecosystem". At the bottom, four icons represent "Scale & integrality in design", "Time & resource savings", "Lower cost implementations", and "Expert partner ecosystem". On the right side of the page, there is a vertical sidebar with buttons for "Feedback", "Report", and "Contact". A video player window on the right shows a man in a white shirt standing in front of a screen displaying data. The left sidebar contains navigation links for "Internet of Things", "Professional services", "Overview", "Features", "IoT resources", and "Managed Services".

AT&T offers what they call professional services for the Internet of Things.



Professional Services (con't)

- <https://www.business.att.com/enterprise/Family/internet-of-things/iot-professional-services/>
-

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I understand what that is." Then they broke up managed services.



The screenshot shows a Microsoft Word document window. The title 'Managed Services' is at the top, followed by the subtitle 'Running an IIoT System'. Below the subtitle is a bulleted list of text. On the left side of the slide, there are four small thumbnail images of other presentation slides, likely from the same deck.

• "Managed services are considered crucial, as they are directly related to customer experience; these services help companies sustain their positions in the market. Moreover, it has become difficult for companies to focus on core business processes and support IIoT functions, which, in turn, increases the significance of managed services. These services offer technical skills that are required to maintain and update software in the IoT ecosystem. All the pre- and post-deployment queries and needs of customers are addressed under the managed services area. Integrated facility management, consultancy, round-the-clock help desk, finance and accounting are some of the upcoming managed services required by operators. This segment is mainly driven by the increasing adoption of outsourced managed services in the IoT market."

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I understand what that is." Then they broke up managed services.



Managed Services

- <https://www.ericsson.com/spotlight/services/managed-services/>
-

Ericsson logo and URL: https://www.ericsson.com/spotlight/services/managed-services/

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So Ericsson talk about managed services.



INTERNET OF THINGS (IoT)

Reinvent processes, create new services, and capture new revenue

IoT Connectivity IoT Connectivity Management IoT Accelerator Platform IoT Monetization IoT Security

IoT in action IoT Lifecycle Management Telecom service provider

Home | Internet of Things



IoT technology and innovation

So Ericsson talk about managed services.