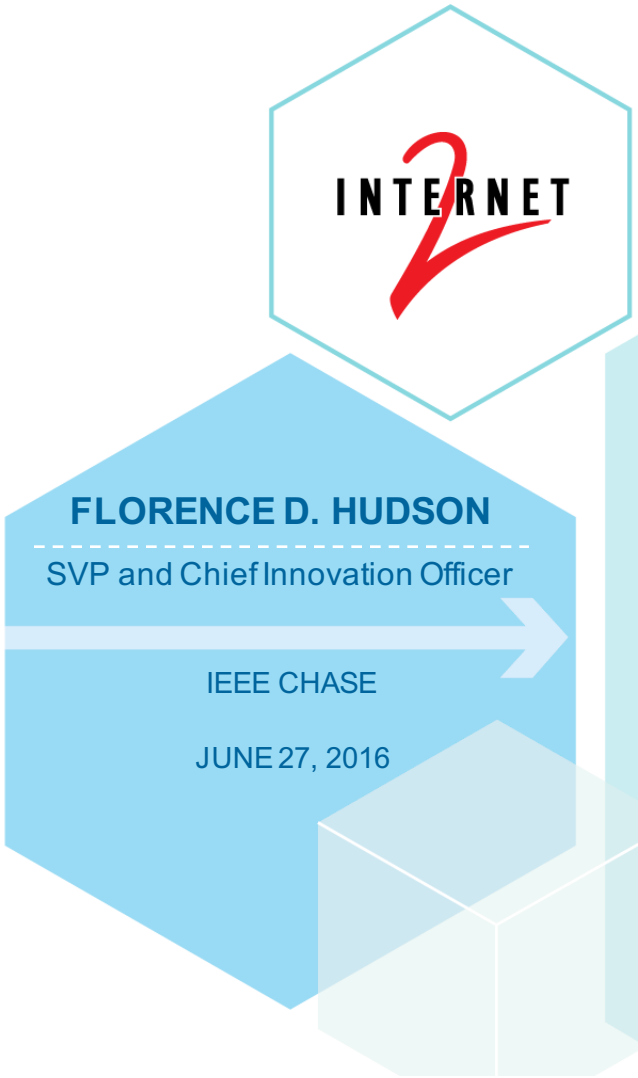


FLORENCE D. HUDSON

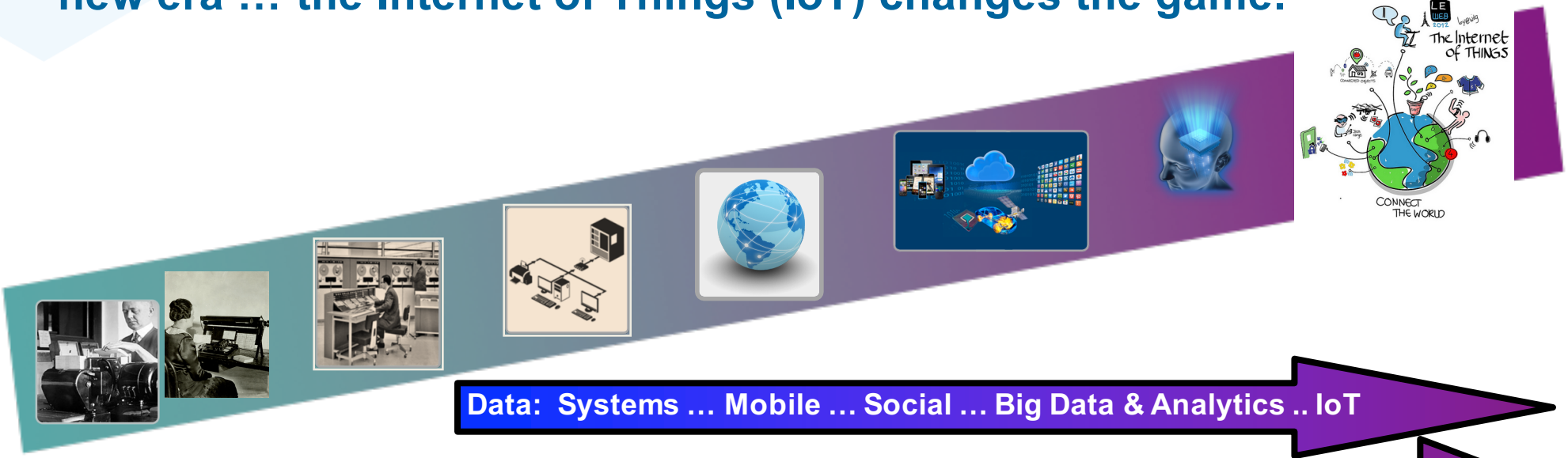
SVP and Chief Innovation Officer

IEEE CHASE

JUNE 27, 2016

IT deployed in the World of Smart Cities and Connected Healthcare

Advances in technology and cultural evolution are ushering in a new era … the Internet of Things (IoT) changes the game.



Data: Systems … Mobile … Social … Big Data & Analytics .. IoT

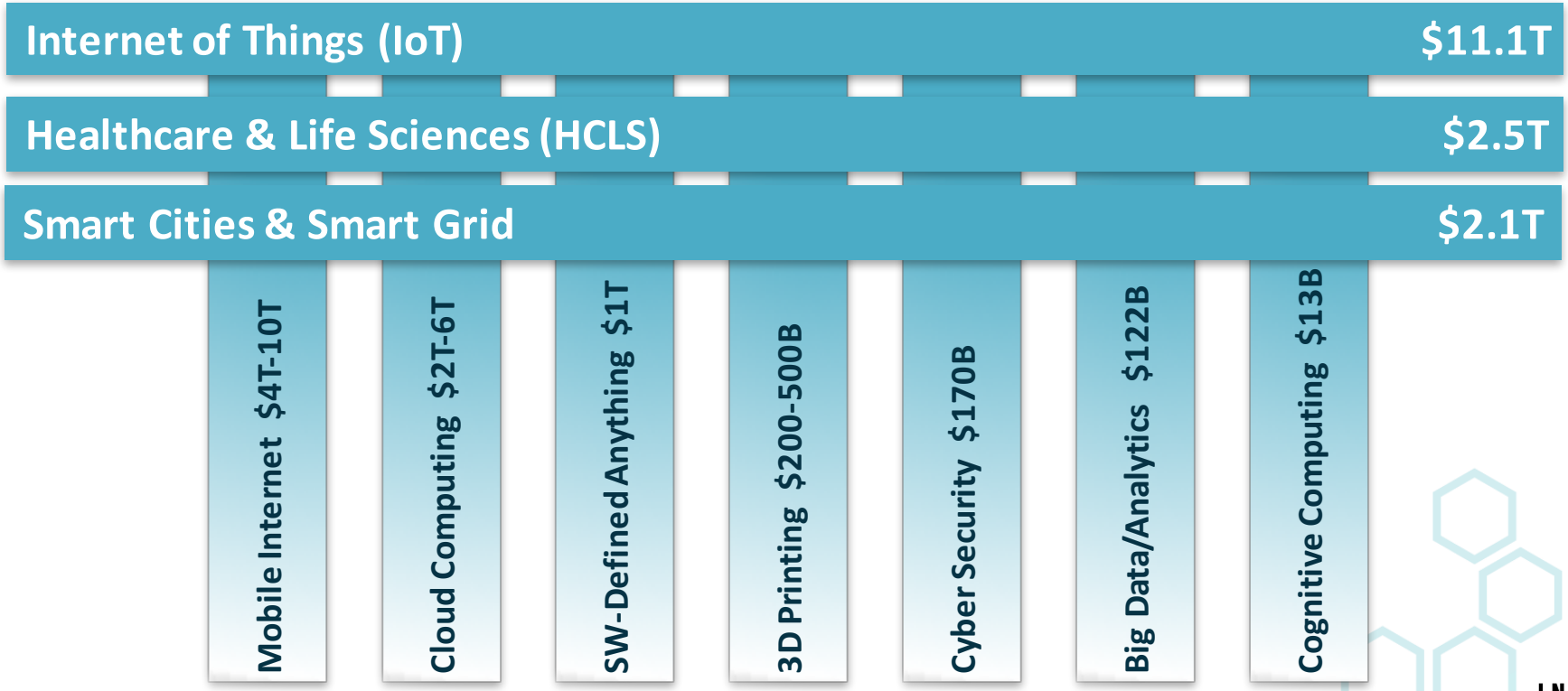
Computing: Centralized … Distributed … WWW … Personal … Cloud … Everywhere

Systems: Tabulating … Programmable … Cognitive

1900s 60s 80s 90s 2010s

INTERNET 2

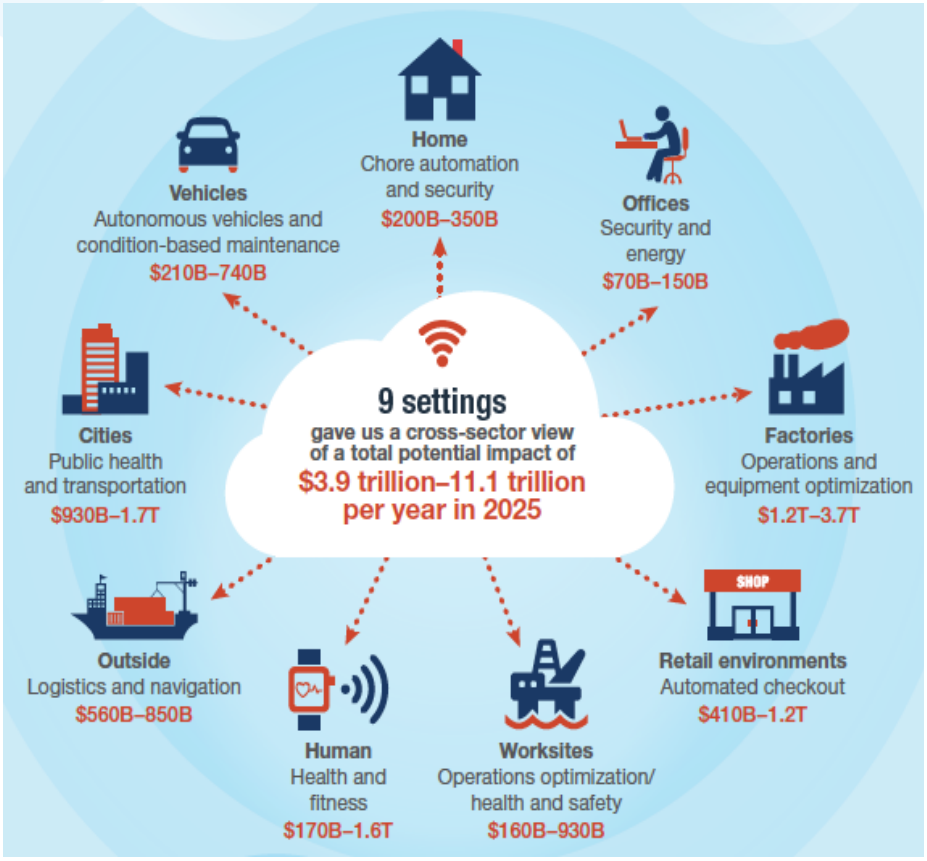
The Internet of Things, Healthcare & Life Sciences, and Smart Cities could represent $15T in global economic value in 2025.



Economic value includes revenues, cost reductions & service improvements achieved

Sources: Internet2 CINO analysis; BizTech; Deloitte; Consultantcy.uk; Forbes; Markets and Markets; McKinsey; US Department of Agriculture, Economic Research Services.

In 2025, the Internet of Things could contribute $11T of global economic value.

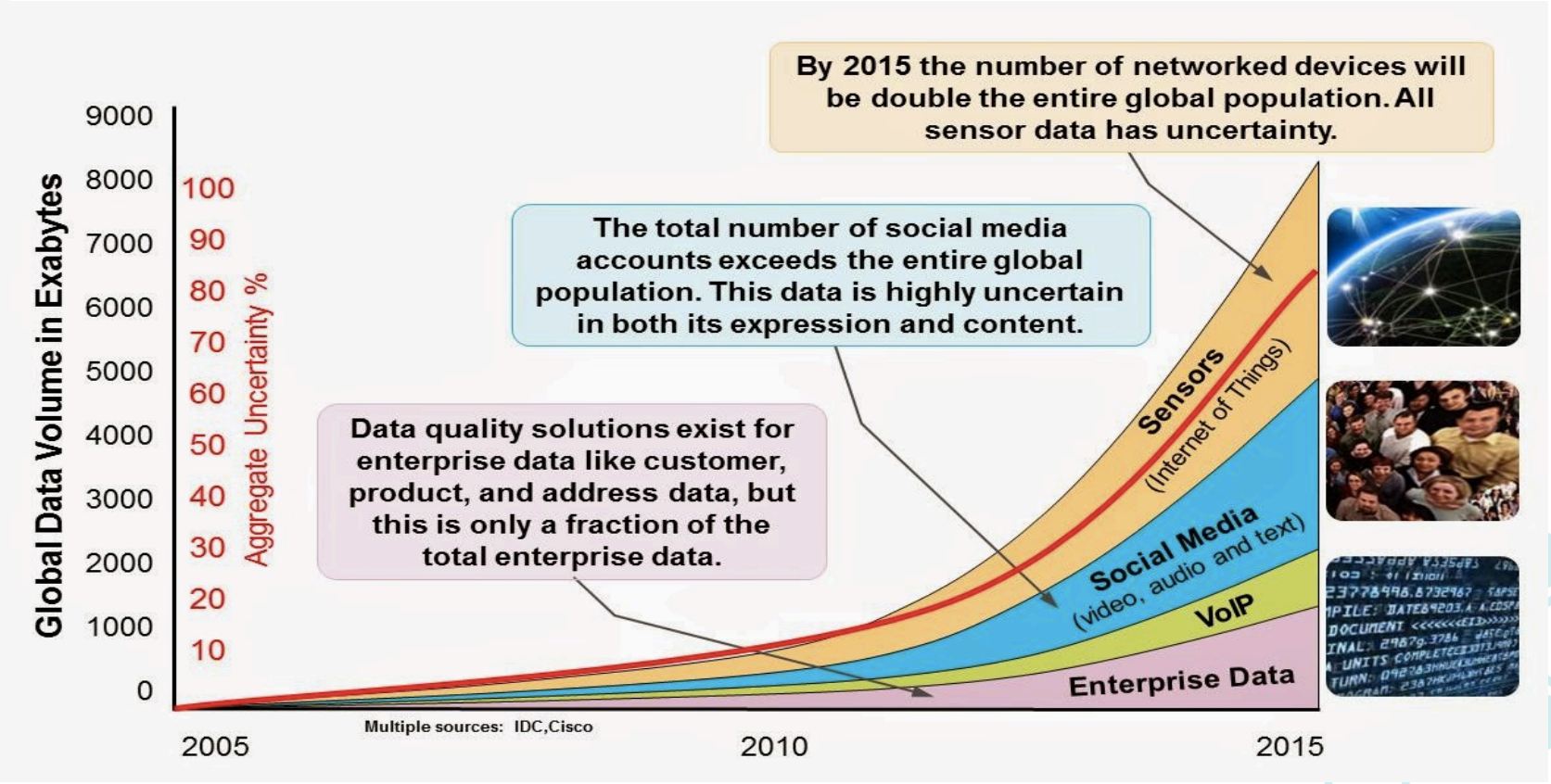


Internet of Things will connect billions of devices, generate large volumes of data, create transformational value, and need a secure network.

- IoT applies across many industries and use cases
- As the physical world becomes connected to the digital world, more "things" will be at play
  - 2014: 13B+ Internet of Things devices
  - By 2020: 25B to 200B "things" will be connected
- IoT is projected to deliver 2x IT economic value, representing 10% of global GDP
- Amount of IoT data will be ENORMOUS
  - Zettabytes (10^{21}) by 2020
  - Then Yottabytes (10^{24})
  - Then Brontobytes (10^{27})

Source: McKinsey "Unlocking the Potential of the Internet of Things." June 2015.

The Internet of Things and social media generate the majority of new data.

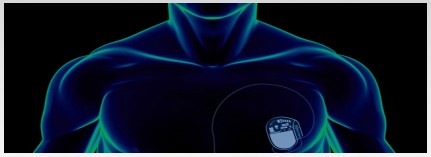


IoT risk and security awareness is increasing … and highlighting the need for security research and development.

Vehicle Hacking

https://www.youtube.com/watch?v=MK0SrxBC1xs

Global Positioning System Spoofing



Healthcare Device Hacking

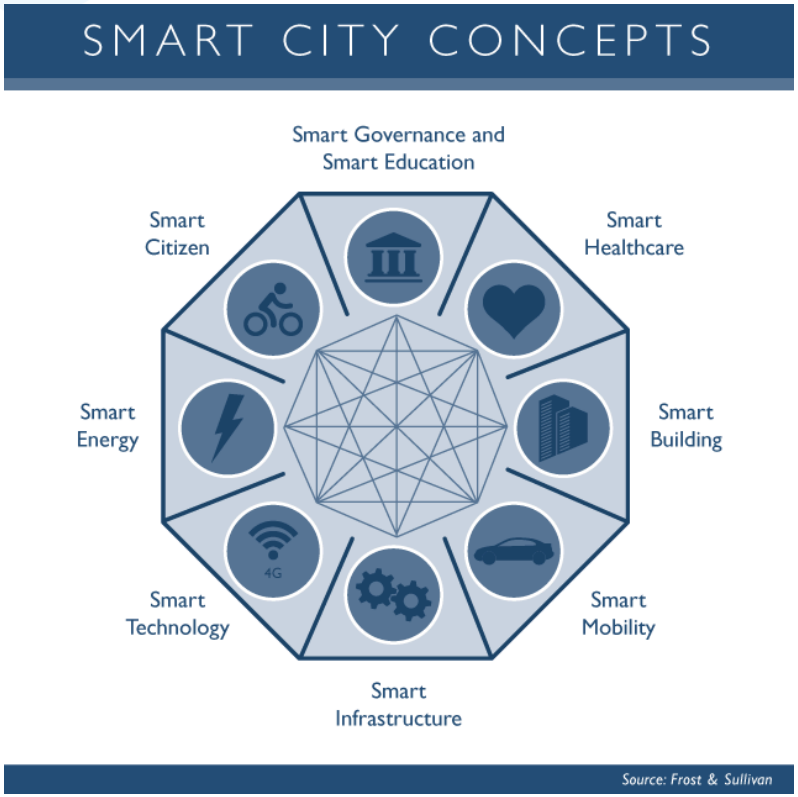
Industrial Hacking

Smart Home Hacking

National Transportation Safety Board Connected-Car Mandate

Sources: npr.org; thehackernews.com; spectrum.ieee.org; cnn.com; technologyreview.com; politico.com.

Smart Cities, Campuses, & Communities will be built on a foundation of Internet of Things technologies.



The White House "Smart Cities" MetroLab initiative will help communities tackle key challenges.

- 35 city-university partnerships including 30 Internet2 university members across the country are participating
- Focused on incorporating data, analytics and innovation
- Development of "Internet of Things" applications testbeds
- Industry members include Cisco, GE, IBM, Microsoft
- Developing multi-sector, intercity collaborative models

Smart Campus initiatives enable American College and University Presidents' Climate Commitment signees to deliver results.

Sources: Consultantcy.uk, "Smart City Market Revenues to Grow to 2 Trillion by 2020." 27 August 2015; Forbes, "Smart Cities – A $1.5 Trillion Market Opportunity." 19 June 2014; ACUPCC Reporting System; The White House, "FACT Sheet: Administration Announces New 'Smart Cities' Initiative to Help Communities Tackle Local Challenges and Improve City Services." September 2015.

Future wireless cities will be an inter-connected “system of systems” to improve efficiency, safety, quality of life, energy use, and environment.

Mesh Networks

V2V, V2I, V2H, V2P

Smart Grid / MicroGrid

Smarter Transportation

Smart Homes/ Buildings

Industrial M2M

Connected Healthcare

Safety

Connected Citizens

What can we enable if we think across the system of systems?

Smart Grids are a key step in the development of Smart Cities/Campuses, and require end to end trust and security.

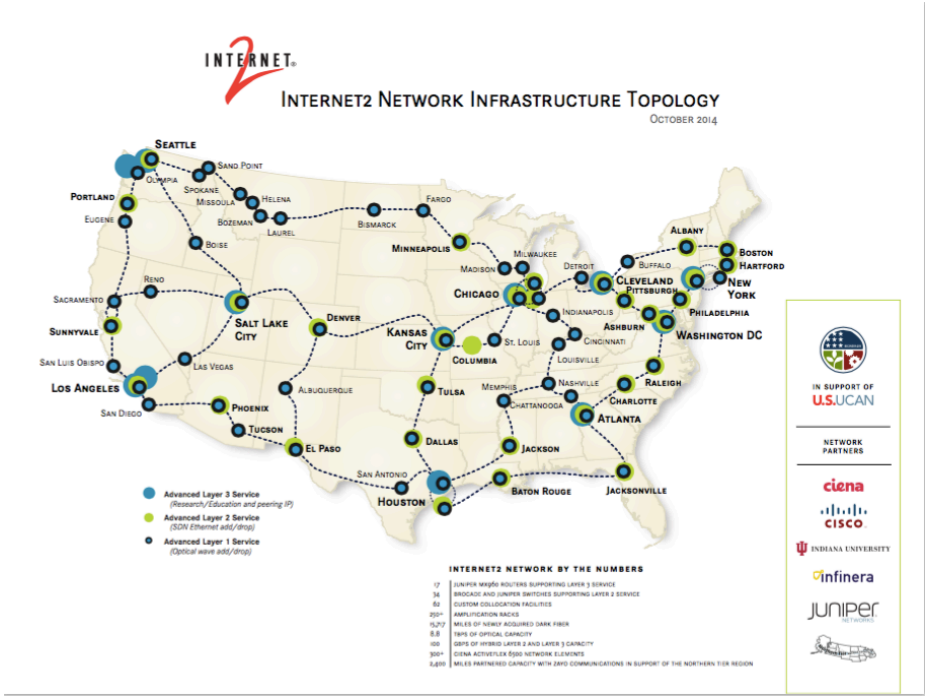
Smart Grid value is transformational and positively impacts:

- Transmission and network optimization
- Optimized renewables integration
- Distribution automation
- Advanced metering infrastructure
- Analytics for pattern recognition & optimization
- Cybersecurity for threat avoidance, identification and analysis

Universities are leveraging the Internet2 network for Smart Grid testbeds.

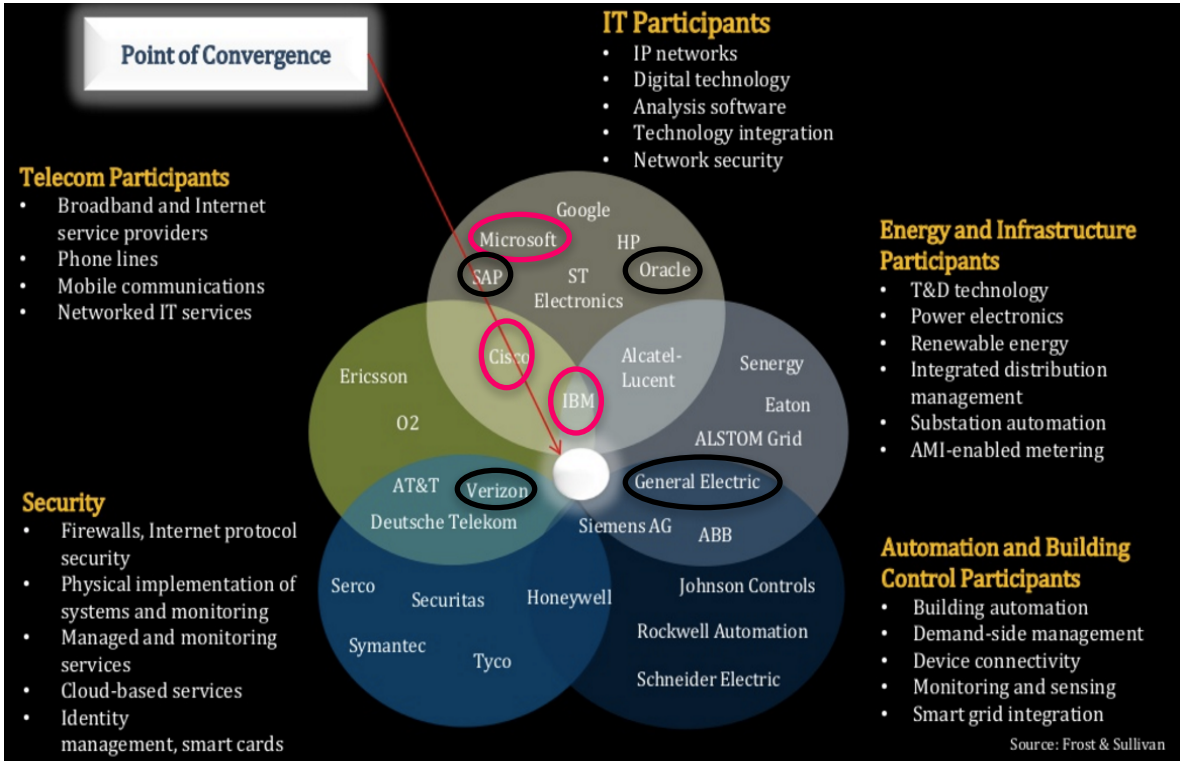
Source: GreenTechMedia, "Smart Grid Market to Surpass $400 Billion Worldwide by 2020." 13 August 2013.

National and Regional Research & Education networks can enable testbeds for smart city and grid systems.



- Provide connections to universities, labs, industry, and HPC environments
- Interconnections between smart cities, communities, grids, microgrids

Internet2 has relationships with key players in the Smart Cities technology landscape and is starting a Smart Campus Initiative.



Internet2 has created a Smart Campus / Smart Cities initiative including:

- Arizona State University
- City University of New York
- Indiana University
- Marshall University
- Princeton University
- University of Maryland-Baltimore County
- University of Pittsburgh
- University of Washington
- University of Wisconsin at Madison
- Virginia Tech

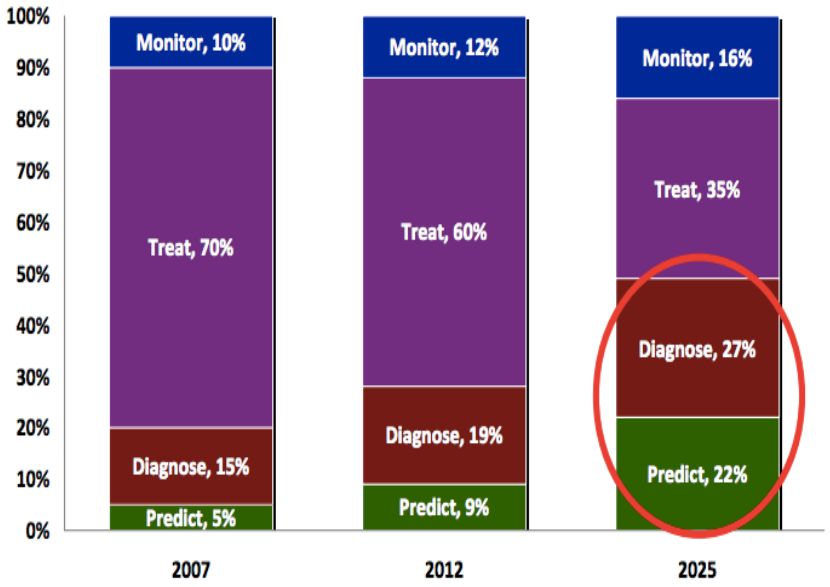
○ = Internet2 IoT Working Group Industry Participant

○ = Internet2 Industry Partner Only

Source: Frost & Sullivan, "Strategic Opportunity Analysis of the Global Smart City Market." 30 August 2013.

The Internet of Medical Things enhances monitoring, predicting, diagnosing, and management of health and wellness.

Healthcare Spending by Type of Activity



Remote monitoring, diagnosis and prediction becomes much more viable in an Internet of Medical Things environment.

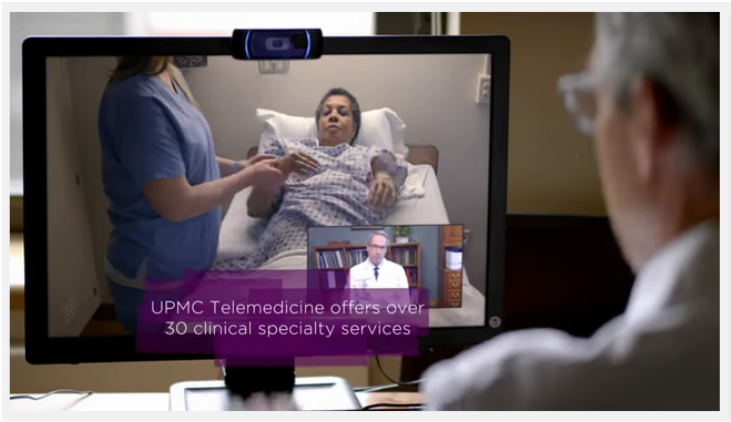
- Connected personal biomedical devices
- Medical consultations via video
- Diagnostic insights via devices, video, and in person

Exponential value can be achieved for physicians, patients, and health outcomes.

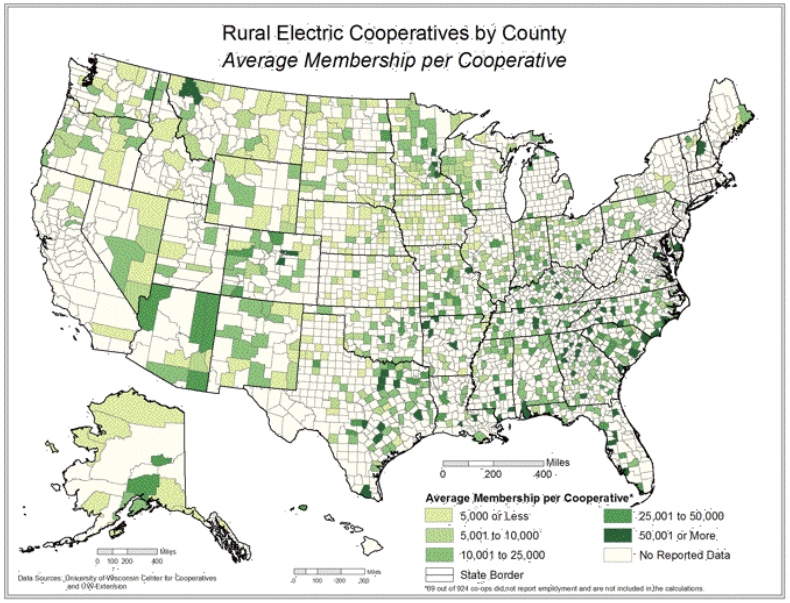
Patient privacy concerns, security, trust, identity and regulatory compliance are particularly important for a successful implementation.

Sources: Frost & Sullivan, "Strategic Opportunity Analysis of the Global Smart City Market." 30 August 2013; Deloitte, "Healthcare and Life Sciences Predictions 2020." November 2014.

Serving citizens in rural settings is a critical need for smarter wireless cities & communities, particularly for Telemedicine and Smart Grids.



University of Pittsburgh Medical Center Telemedicine
http://bit.ly/1SIVUhh



Mobile Internet is an enabler of IoT, Smart Cities/Campuses, and Healthcare transformation.

Internet-enabled portable devices are now a way of life:

- Potential for 9.2B total mobile subscriptions by 2020
- Mobile computing devices, high-speed wireless connectivity, and applications

Healthcare could benefit the most from Mobile Internet.

Consider an aspirational Connected Healthcare scenario including IoT from Kaiser Permanente:
http://www.kp-itcomms.org/mm/digitalhealth/index.html

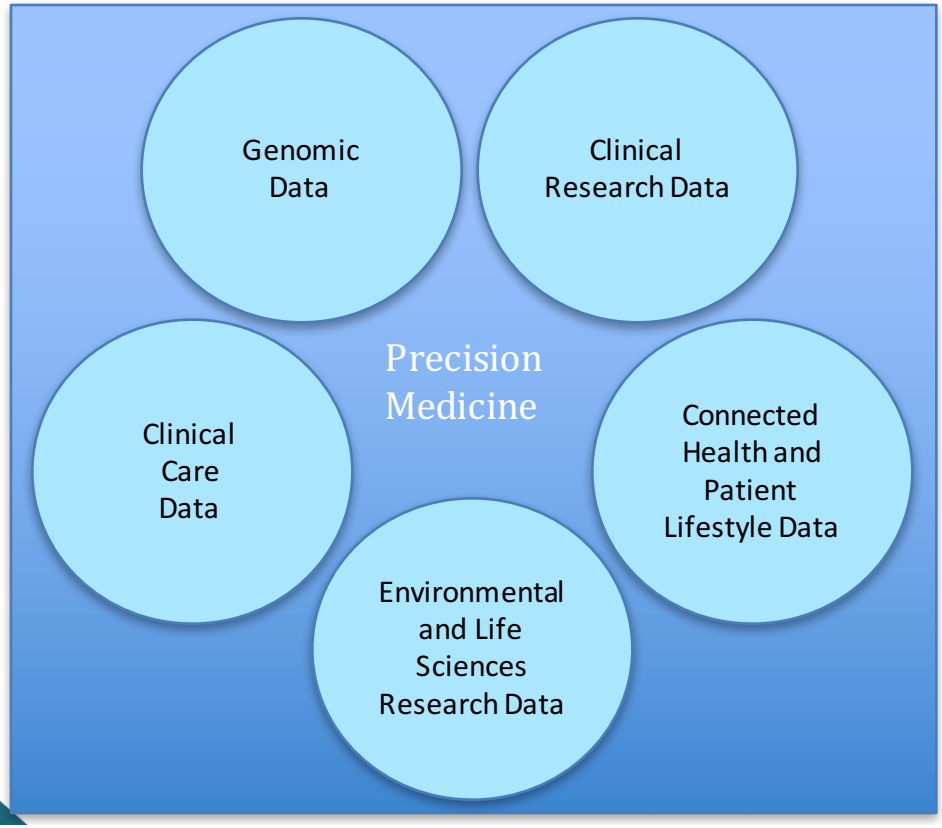
Connecting People to a Healthy Future (2012)

Healthcare Leads Mobile Internet Potential in 2025

Sources: McKinsey, "Disruptive Technologies: Advances That Will Transform Life, Business, and the Global Economy." May 2013; TechCrunch, "6.1B Smartphone Users Globally by 2020, Overtaking Basic Fixed Phone Subscriptions." 2 June 2015.

Healthcare & Life Sciences will increasingly leverage technology for analysis of volumes of data, improving insights and outcomes.

Confluence of data to support Precision Medicine



Large data volumes and analytics opportunity generated by:

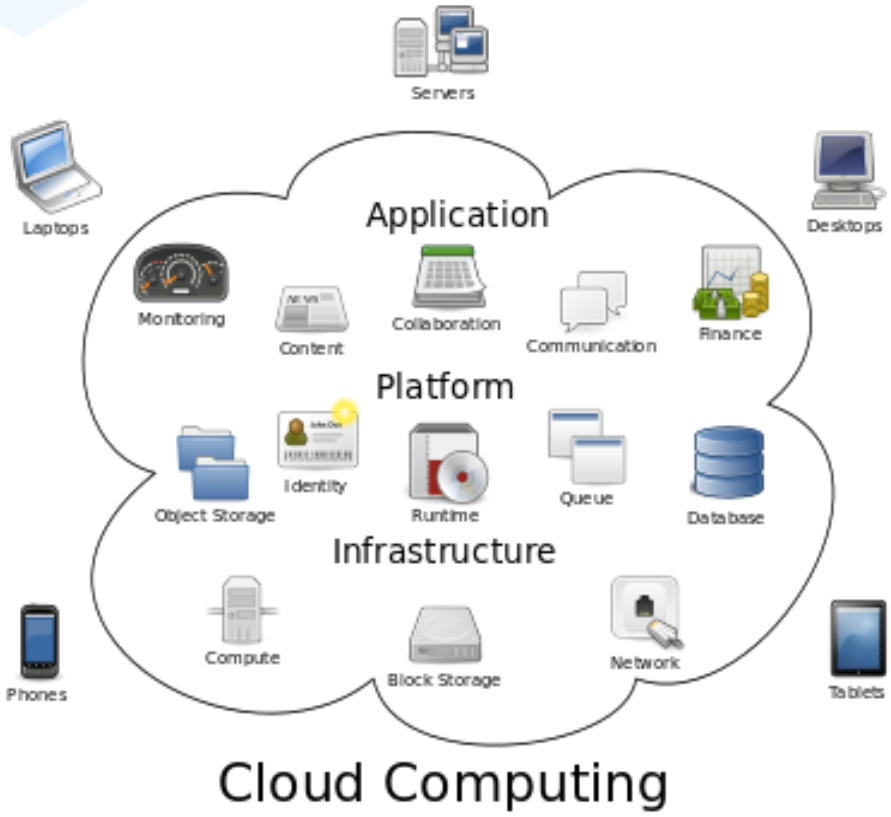
- Genomic data
- Clinical and fundamental research data
- Clinical care data and observations
- EMR/EHR
- Connected health and wellness devices
- Patient input including lifestyle, travel
- Environmental data (weather, pollution)
- Life sciences research data
- Images (tumors, MRIs, etc.)
- Biotechnology, medical technology, pharma

Creating a cognitive computing opportunity

for 21st Century Medicine." September 2015.

INTERNET 2

In 2025, Cloud Computing could contribute $6T in global economic value.



By 2025, most IT and Web applications/ services will be Cloud-based, driving the need for a secure and dependable network.

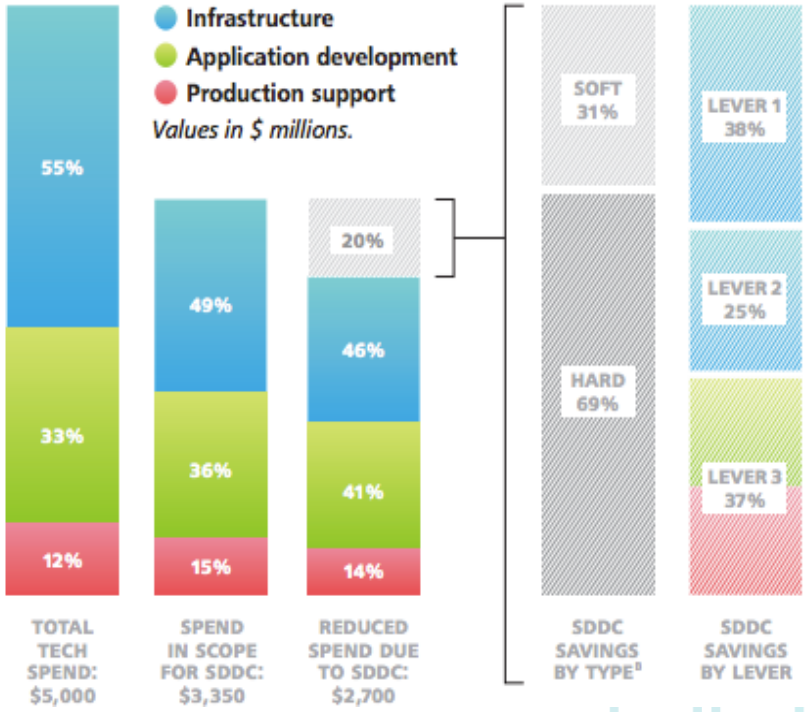
- Cloud Computing enables remote computational work
- Enables Internet-based services growth in on-demand environment
- Cloud computing capabilities become more important and pervasive in an IoT world

Sources: McKinsey, "Disruptive Technologies: Advances That Will Transform Life, Business, and the Global Economy." May 2013; Wikipedia, "Cloud Computing." 30 September 2015.

Software-Defined Anything can reduce IT costs up to 20%, representing up to $1T in reduced costs in 2025.

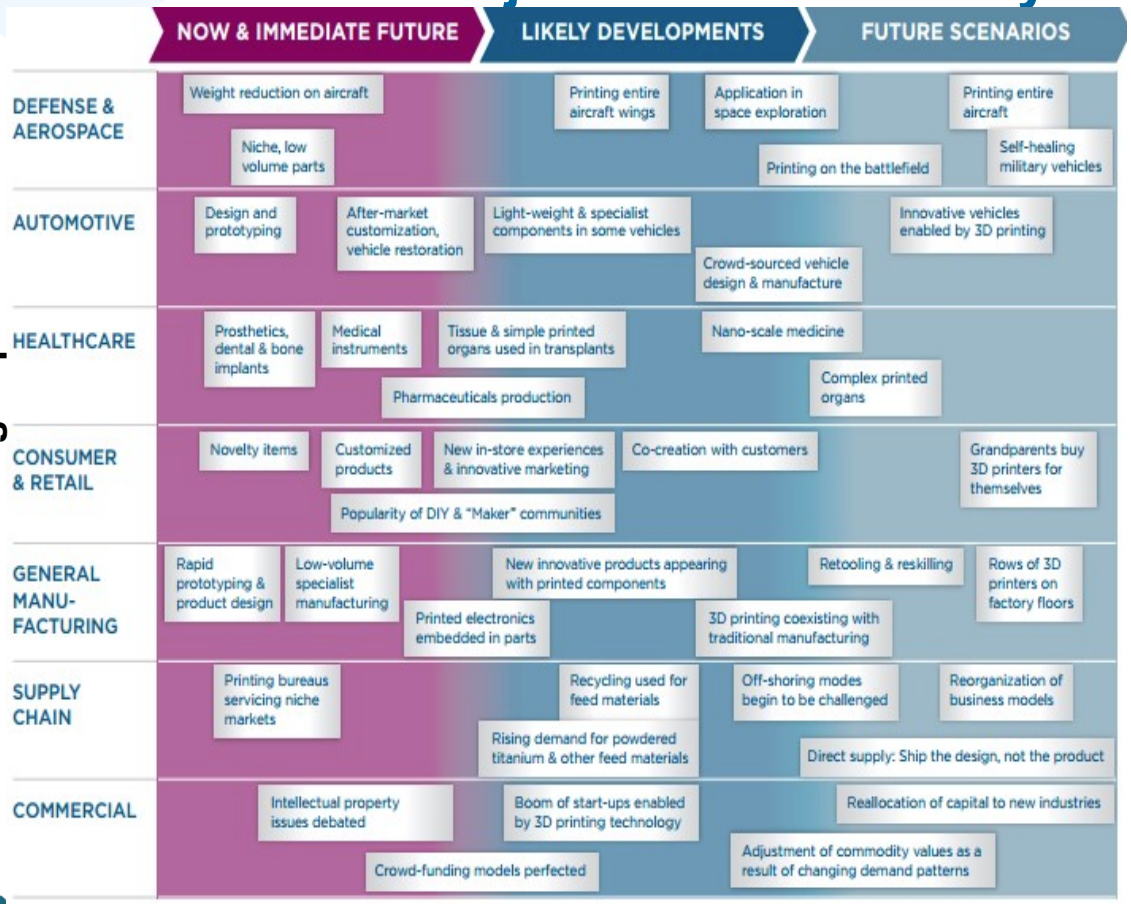
Software-Defined Anything enable efficiencies, reduced costs, and capabilities in a more consumable fashion:

- Rules, models, and code dynamically assemble and configure all needed elements
- Including security, e.g., Software Defined Perimeter (SDP)



Source: Deloitte, "Tech Trends 2015: The Fusion of Business and IT." 3 February 2015.

3D Printing creates physical objects that then become part of the IoT and each object – or collectively – can represent a lot of data.



3D Printing is expected to reach a "tipping point" in the next few years.

- 98% growth in 2015, doubling in 2016
- $1B market 2013, $6B 2017, $600B 2025

And its value can increase over time:

- Lower cost aircraft parts -> self healing aircraft
- Vehicle restoration -> crowd sourced vehicle design
- Dental implants -> printed human organs
- Supply chain business models -> Print on Demand

Sources: Forbes, "2015 Roundup of 3D Printing Market Forecasts and Estimates." 31 March 2015; 3dprintingindustry.com, "Trend Evolution: 3D Printing Trends (Part 1)." 24 February 2014.

Cybersecurity is required for IoT, HCLS, Smart Cities, and Smart Grid to be successful.

79% of organizations have experienced a Cybersecurity event in the past 12 months.

Within two years, 90% of all IT networks will have an IoT-based security breach, although many will be considered "*inconveniences.*" Chief Information Security Officers (CISOs) will be forced to adopt new IoT policies.

"There are two kinds of big companies in the US. There are those who've been hacked, and those who don't know they've been hacked."
- FBI Director, James Corney

Cyber Security is grabbing headlines and will become increasingly important with more connected IoT devices.

- Distributed Denial of Service (DDoS) attacks are increasingly more potent, and one of the most frequent types of incidents
- Key areas for innovation include: detection, response, defense, prediction, prevention
- Critical applications of the Internet of Things require TIPPSS
  - Trust
  - Identity
  - Privacy
  - Protection
  - Safety
  - Security

Sources: IDG, "2015 US State of Cybercrime Infographic." 15 July 2015; IDC, "FutureScape: Worldwide Internet of Things 2015 Predictions." December 2014; IDC, "Thwarting Cyberthreats and Attacks Against Healthcare Organizations." November 2014; Internet2 CINO.

Cognitive Computing – combined with IoT – increases insights and the potential for perpetual optimization.

Cognitive Computing: the combination of humans, machine learning, and predictive modeling…

Vision: ingest and analyze many data types to provide insights for improved outcomes…

Enabling the opportunity for perpetual optimization.

Use cases would include healthcare and smart cities, leveraging tools such as:

- Natural language processing
- Visualization
- Input from text, images, data, including curated data from journals, clinical research, traditional sources, smart devices, sensors, wearables
- "Uncertain data" like social media
- Advanced and predictive data analytics

Sources: BizTech Reports, "Cognitive Computing Market is Expected to Reach $13.7 Billion By 2020, Allied Market Research Finds." 22 June 2015; IBM, "Your Cognitive Future: How Next Gen Computing Changes the Way We Live and Work." January 2015.

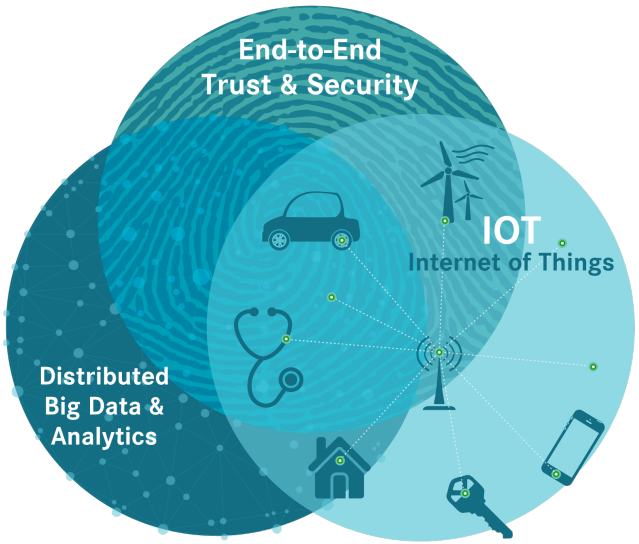
The strategic trends are reflected in the Internet2 Collaborative Innovation Program and Working Groups.

E2E Trust & Security:

- End to End Trust and Security for IoT
- TIPPSS – Trust, Identity, Privacy, Protection, Safety, Security
- SDP (Software Defined Perimeter), Network Segmentation

Distributed Big Data & Analytics:

- Genomics
- Smart Campus / Smart Cities
- Digital Humanities



Internet of Things:

- IoT Sandbox
- Smart Campus / Smart Cities
- Smart Grid Testbed

Strategic trends create opportunities for Research & Education.

- **Research opportunities abound.**
  - Testbeds leveraging Internet2, NRENs and regional networks for applied research in IoT, Smart Campus/Smart Cities, Smart Grid, Healthcare and Life Sciences (HCLS)
  - IoT Sandboxes for collaborative research and application development
  - Innovations for device, chip, app, network, architecture, security, communications, etc.

- **Internet2 and its members can guide HCLS to the next frontier.**
  - Enable leverage of the confluence of various HCLS data sets for precision medicine, including genomic, clinical research, clinical care, lifestyle, and environmental data
  - Connect across multiple new technologies for strategic HCLS areas/use cases: IoT, big data and analytics, end to end trust and security, cognitive computing

- **Potential to positively impact culture and society.**
  - Educate future leaders of an IoT-led economy
  - Lead in addressing current and future challenges and opportunities

Research & Education Community can take action to create the future

- **Develop curricula to build the technical and business leaders of the future economy**
  - Curricula for Internet of Things, Precision Medicine, Smart Campus / Cities / Grids, Informatics
  - Develop new business models, technologies, processes
- **Create technology innovation through research and testbed programs**
  - Smart Campus, Smart City, Smart Grid, Healthcare and Life Sciences testbeds
  - IoT Labs – e.g., at UWMadison, Johns Hopkins Applied Physics Lab
- **Develop new models for improved operation and sustainability of a campus, city, community**
  - IoT to measure, monitor, model, and manage campus / city / community / health / safety operations
  - Cross-functional collaboration for improved outcomes, e.g., IT / facilities / administration / students
- **Attract funding to support member research in strategic domains**
  - Potential funding sources could include agencies, industry, foundations
  - Opportunity for singular or multi-university funding proposals

Thank you

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