GigaBit broadband

Could it/will it/should it change the world, and if so, how?

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TFI COMMUNICATIONS TECHNOLOGY ASSET VALUATION CONFERENCE

TECHNOLOGY FUTURES INC.

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MIT Communications Futures Program

"Defining the roadmap for communications and its impact on adjacent industries."

CSAIL
MIT COMPUTER SCIENCE AND ARTIFICIAL INTELLIGENCE LABORATORY

Future vision: Pervasive, Cloud Computing, Big Data

GigaBit Access: future of Broadband

Video OTT

Big Data, Clouds

Summing Up

Vision of the Internet Future : Pervasive Computing
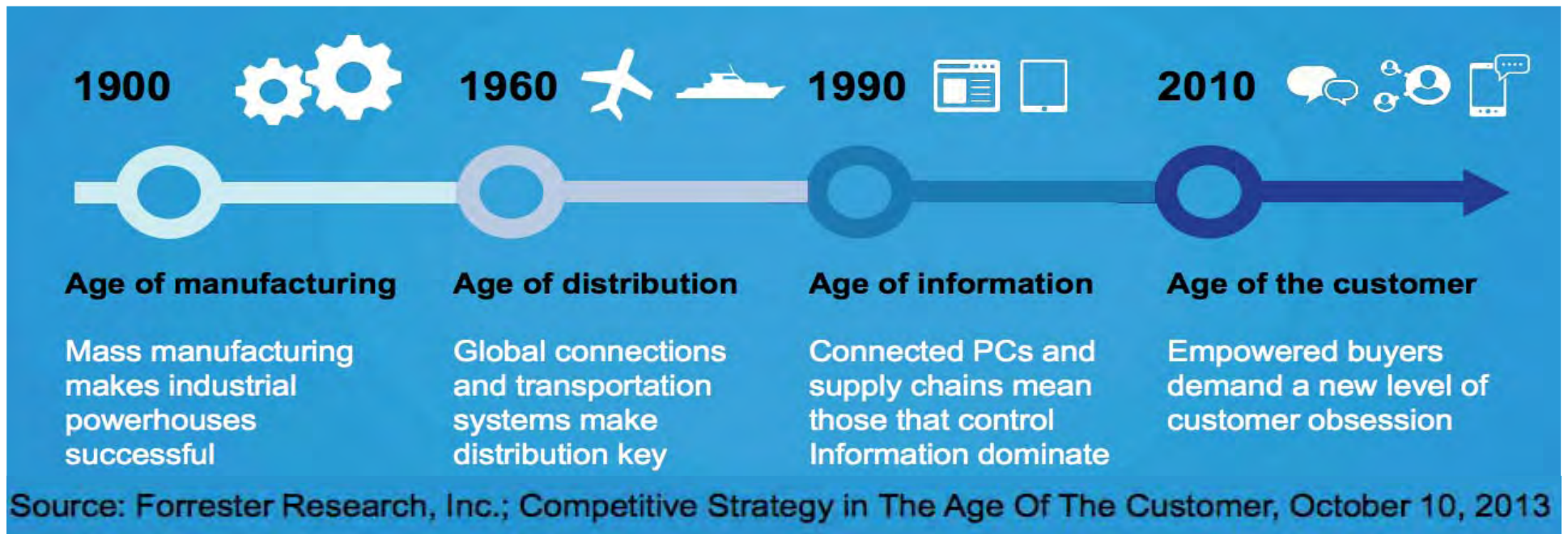
Features
Always on/Everywhere connected
Smart (distributed) e.g., Internet of Things, CPUs in everything
Wireless & Mobile

Capabilities
Adaptive, Dynamic, Context aware
Real-time
Personalized (customized)

Implications
End-user empowerment
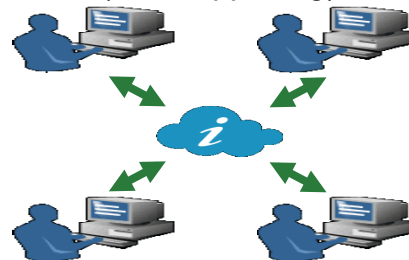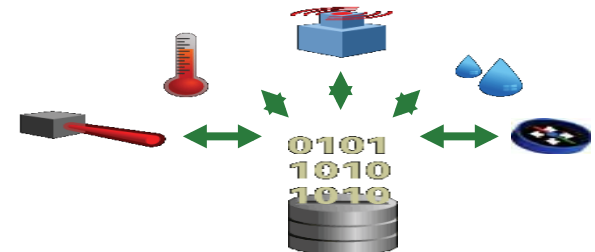Real-time decision-making
Automated

Source: Forrester Research, Inc.; Competitive Strategy in The Age Of The Customer, October 10, 2013

1900	1960	1990	2010
Age of manufacturing	**Age of distribution**	**Age of information**	**Age of the customer**
Mass manufacturing makes industrial powerhouses successful	Global connections and transportation systems make distribution key	Connected PCs and supply chains mean those that control Information dominate	Empowered buyers demand a new level of customer obsession

Data Processing

Weeks
Batch
Megabytes
Punch Cards
Few People

Internet
(Still Happening)

Days
Request/Reply
Terabytes
Human
Many People

Real Time

Minutes
Automated
Exabytes
Event Driven
Beyond People

NATIONAL BROADBAND PLAN
CONNECTING AMERICA

March 2010

Broadband is the great infrastructure challenge of the early 21st century.

THE PLAN by ISSUES

Learn how the National Broadband Plan is shaping the future of issues that matter to Americans. Get key highlights in the plan about:

> **ECONOMIC OPPORTUNITY**

> **EDUCATION**

> **HEALTH CARE**

> **ENERGY AND THE ENVIRONMENT**

> **GOVERNMENT PERFORMANCE**

> **CIVIC ENGAGEMENT**

> **PUBLIC SAFETY**

(U.S. hardly unique. Most OECD countries have Digital Agendas with National BB Plans.)

Source: http://www.broadband.gov/plan/

Broadband Future : Clouds & GigB (100Mbps+ by 2020)

Pervasive computing vision

Always on/everywhere connected (wireless)

Mobility

Real-time decision-making

Dynamic scalability, reliability, just-in-time

Drivers : exponential traffic growth...

Faster, cheaper, smaller CPU, displays, storage, I/O

Internet of Things

Video, interactivity, richer multimedia, automated

Mobility : Anywhere/Everywhere/All time scales

Big Data : everything measurable/instrumented

Challenges for GigB access

Investment keeps pace with traffic

    Faster devices, access, cores accelerate traffic. Positive feedback.

    Mobility makes traffic more bursty, less predictable

    Interactivity/mobility/personalized means capacity needs more symmetric

Rapid economic depreciation, long-lived, uncertain

    Technology/Market/Business/Regulatory Uncertainty. Timing.

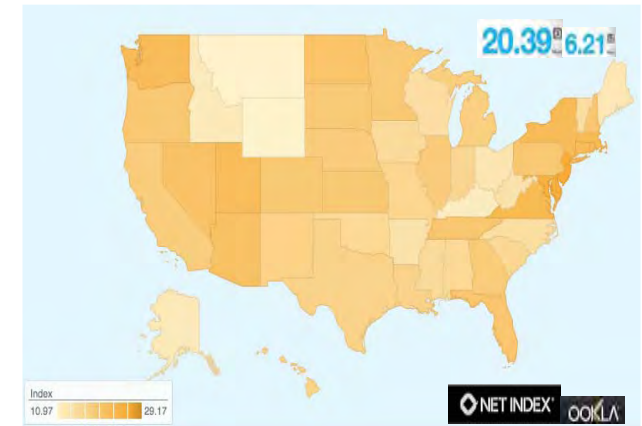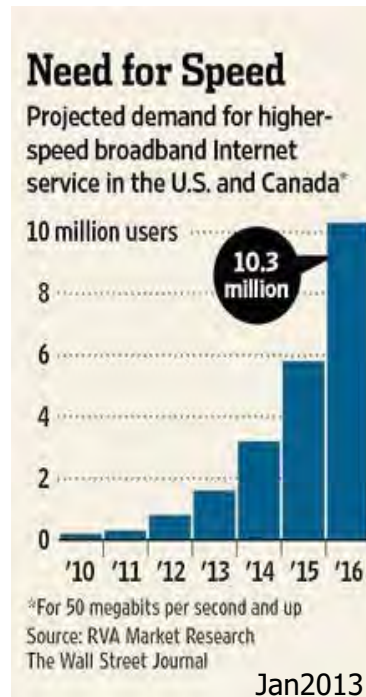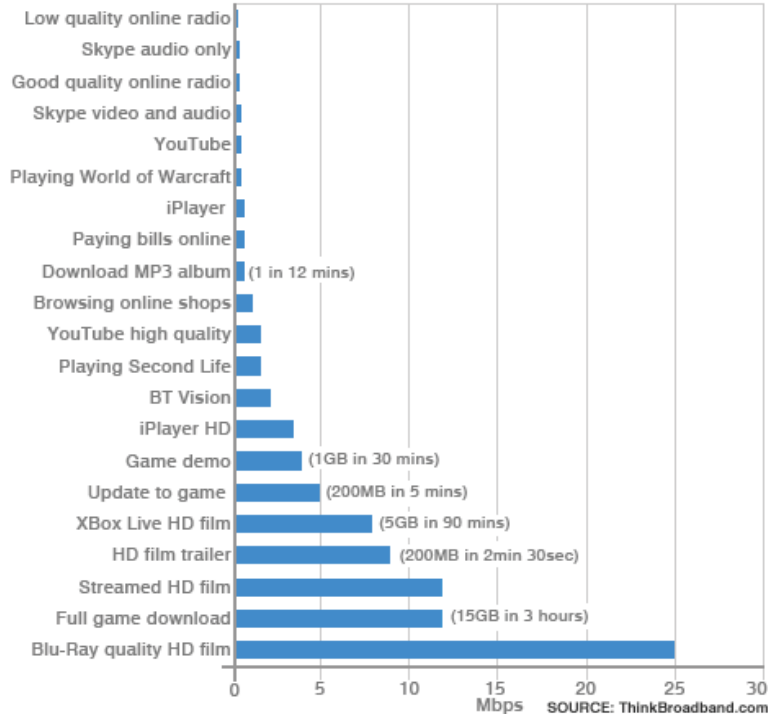   Interoperability & moving bottlenecks

    Competition (Substitutes)

    Value capture & Pricing (cost-recovery). Free-riding

(Clouds, Big Data confront the same....)

Do we need 1Gbps broadband? Timing.

DOWNLOAD OF CONTENT

Content	Note
Low quality online radio	
Skype audio only	
Good quality online radio	
Skype video and audio	
YouTube	
Playing World of Warcraft	
iPlayer	
Paying bills online	
Download MP3 album	(1 in 12 mins)
Browsing online shops	
YouTube high quality	
Playing Second Life	
BT Vision	
iPlayer HD	
Game demo	(1GB in 30 mins)
Update to game	(200MB in 5 mins)
XBox Live HD film	(5GB in 90 mins)
HD film trailer	(200MB in 2min 30sec)
Streamed HD film	
Full game download	(15GB in 3 hours)
Blu-Ray quality HD film	

Mbps SOURCE: ThinkBroadband.com

Need for Speed

Projected demand for higher-speed broadband Internet service in the U.S. and Canada*

10 million users

10.3 million

*For 50 megabits per second and up
Source: RVA Market Research
The Wall Street Journal

Jan2013

20.39 6.21

Index 10.97 — 29.17

NET INDEX OOKLA

Country/Region	% Above 10 Mbps	QoQ Change	YoY Change
– Global	14%	13%	38%
1 South Korea	45%	-8.6%	-6.5%
2 Japan	43%	5.8%	18%
3 Switzerland	37%	21%	71%
4 Latvia	33%	13%	29%
5 Réunion	33%	35%	-
6 Hong Kong	32%	-1.9%	23%
7 Netherlands	31%	8.5%	66%
8 Czech Republic	27%	24%	88%
9 Belgium	25%	23%	80%
10 United States	24%	2.3%	43%

Figure 14: High Broadband (>10 Mbps) Connectivity Akamai

Multiple BB users per home
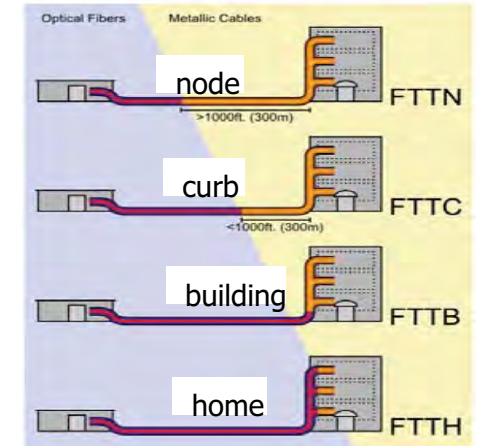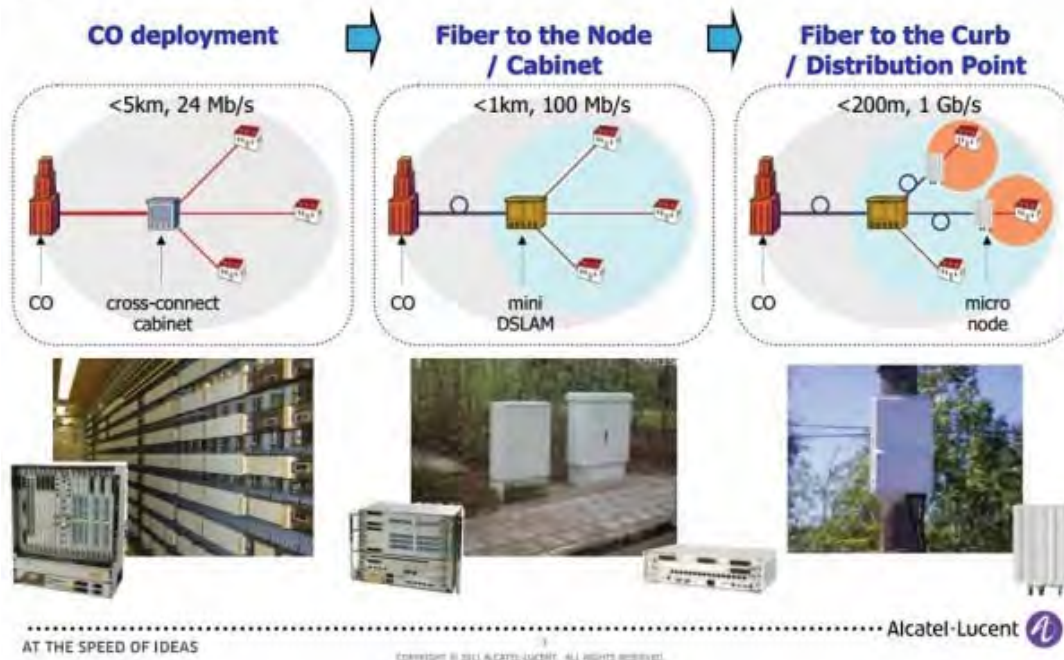Faster better
Competition. No one wants yesterday's paper.
Mobile small cells ⇔ fixed/mobile integration ⇔ shared infrastructure

Fiber-to-the-X (FTTX)
-- Gbps Broadband
-- Mobile Backhaul

Optical Fibers | Metallic Cables
node — FTTN >1000ft. (300m)
curb — FTTC <1000ft. (300m)
building — FTTB
home — FTTH

Reality
gradual deployment of fiber deeper in network

CO deployment ⇒ Fiber to the Node / Cabinet ⇒ Fiber to the Curb / Distribution Point

<5km, 24 Mb/s | <1km, 100 Mb/s | <200m, 1 Gb/s

CO — cross-connect cabinet | CO — mini DSLAM | CO — micro node

AT THE SPEED OF IDEAS

Alcatel·Lucent

BENEFITS

Capacity (QoS, options)
Future proof
Lower OPEX (?)
Natural monopoly (?)

RISKS

Penetration (revenue) v. Coverage (costs)
Chicken-Egg timing
Competition
Regulatory uncertainty (Federal & local)

Video & OTT : where is the traffic driver taking us?

Value creation or redistribution? **Better be about new value!**

    Revenue: $/view for cable v. OTT? CDs v. Spotify?

    Cost: Broadcast-over-RF v. unicast-over-IP?

Shared network cost recovery? **A worsening challenge**

    Triple Play Bundle Pricing: Telephone/SMS & now TV?

Future of content? **end-user generated in a mobile BB world**

    Entertainment: how much TV can we watch anyway? What device?

    User-generated: YouTube/Mobile/Distributed/Personal

    Rich Multimedia: interactivity/gaming/social media

    Monitoring: cameras everywhere, machines can watch too

Network challenge? **Capacity, capacity, capacity.. & storage, coding**

    Traffic: more symmetric, unpredictable (bursty)

    In-the-cloud replaces on-the-device, rent rather than own…

    Rights management: who owns the meta data?

Big Data is a Demand Accelerator

Big data can generate significant financial value across sectors

US health care
- $300 billion value per year
- ~0.7 percent annual productivity growth

Europe public sector administration
- €250 billion value per year
- ~0.5 percent annual productivity growth

Global personal location data
- $100 billion+ revenue for service providers
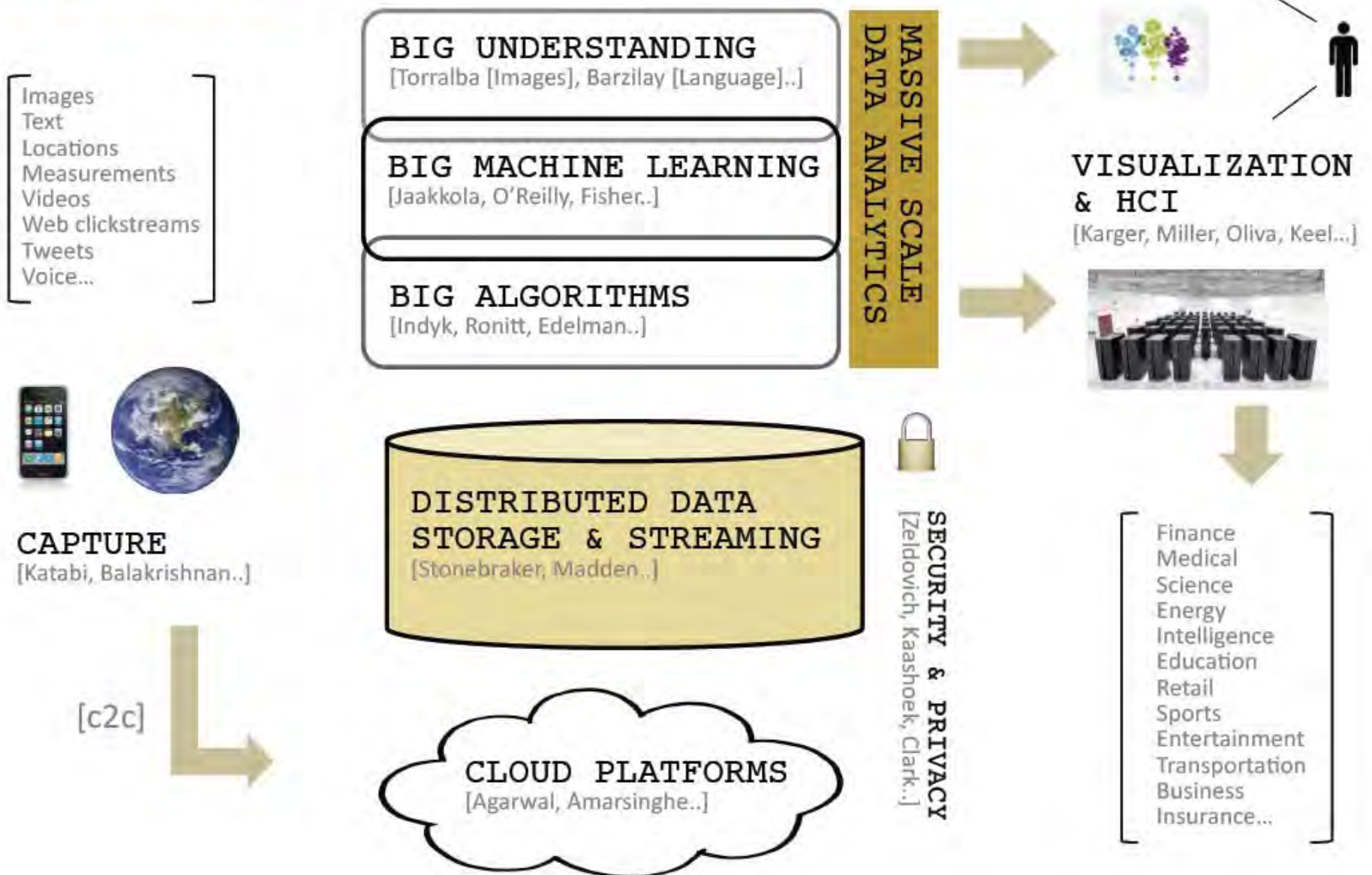- Up to $700 billion value to end users

US retail
- 60+% increase in net margin possible
- 0.5–1.0 percent annual productivity growth

Manufacturing
- Up to 50 percent decrease in product development, assembly costs
- Up to 7 percent reduction in working capital

SOURCE: McKinsey Global Institute analysis

Source: McKinsey (2011), "Big Data: the next frontier for innovation, competition, and productivity"

bigdata@csail
taming the data deluge

INSIT!

Images
Text
Locations
Measurements
Videos
Web clickstreams
Tweets
Voice...

BIG UNDERSTANDING
[Torralba [Images], Barzilay [Language]..]

BIG MACHINE LEARNING
[Jaakkola, O'Reilly, Fisher..]

BIG ALGORITHMS
[Indyk, Ronitt, Edelman..]

MASSIVE SCALE DATA ANALYTICS

VISUALIZATION & HCI
[Karger, Miller, Oliva, Keel...]

CAPTURE
[Katabi, Balakrishnan..]

[c2c]

DISTRIBUTED DATA STORAGE & STREAMING
[Stonebraker, Madden..]

SECURITY & PRIVACY
[Zeldovich, Kaashoek, Clark..]

CLOUD PLATFORMS
[Agarwal, Amarsinghe..]

Finance
Medical
Science
Energy
Intelligence
Education
Retail
Sports
Entertainment
Transportation
Business
Insurance...

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Clouds: next big thing for network providers?

Value proposition : transport + distributed computing + storage

  Just-in-time/anywhere on-demand resources

  Resource pooling

  Thin/thick clients, mobile/fixed, wired/wireless

  Reliability: redundancy, diverse routing, security (?)

  Energy efficiency & cost saving : scale economies, maintenance

Clouds: who owns assets? Customer relationship? Application?

  XaaS (X=I, P, S, ?): General purpose/specialized? Public/private?

  Smart edges (Dumb pipes) v. Smart networks

Challenges: divide the pie!

  Control ⇔ Interoperability

  Shared resources ⇔ Cost recovery

  Regulatory uncertainty: (telephony) PSTN ➔ cloud computing utility

Cloud Services : $28B (2011) ➜ $70.8B (2015)

SaaS ($13B), PaaS ($3B), IaaS ($12B)…. 26% CAGR

Worldwide Public IT Cloud Services Segmented by Primary
Market, 2009–2015

Source: IDC, 2012

Source: http://media.amazonwebservices.com/idc_aws_business_value_report_2012.pdf
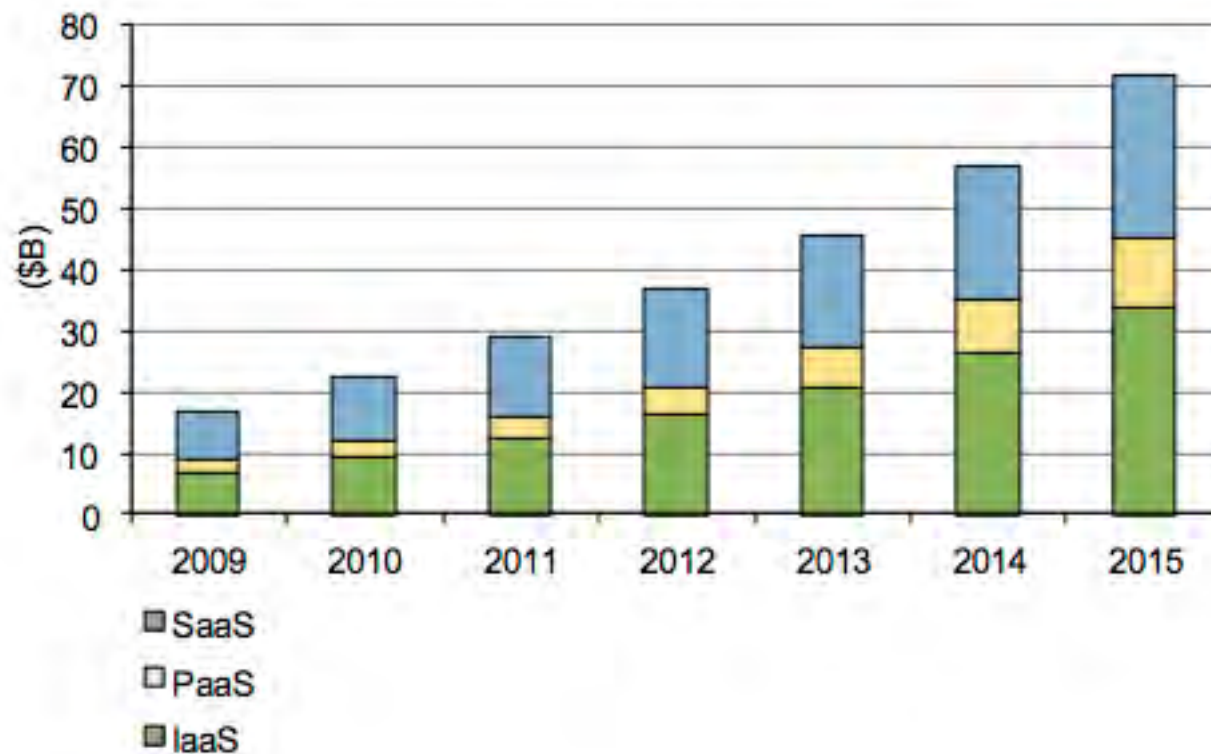
Summing up

Future *IS* Big Data, Cloud Computing, Gigabit Access

Lots of challenges

Multiple bottlenecks: risk or opportunity in eye of beholder

Competition: mix-and-match, silos and platforms

Uncertainty: technical, market, regulatory

Faster clockspeed: competitive advantage may be short lived

Video? yes but had better be user-generated & interactive

Traffic? Lots more, more symmetric, more bursty

Big Data? early stages (real-virtual world integration)

Clouds? yes, multiple clouds and uncertain who captures value

Thanks for your attention!
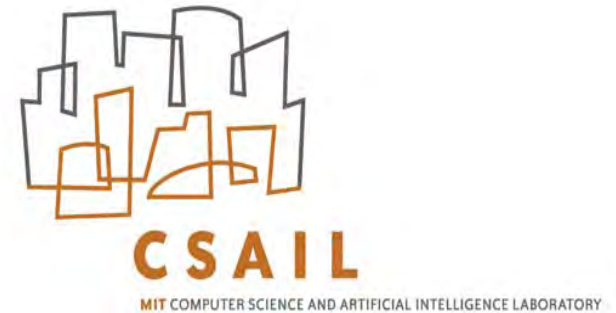
Questions: wlehr@mit.edu

Websites:
http://cfp.mit.edu
http//csail.mit.edu/~wlehr

CSAIL

MITSloan
MANAGEMENT

MIT Media Lab
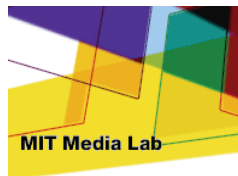
Our Vision at the Communications Futures Program (CFP) is to define the roadmap for communications and its impact on adjacent industries. CFP is a cross cutting partnership between academia and industry, with industrial partners from across the value chain.

Multidisciplinary : technology, business strategy/economics and policy

Cross Value Chain : across industry … chips to boxes to services to apps, across functions… R&D to strategy to operations, industry to academia to policy

Open Communications : focus on destabilizing shifts of intelligence and control between network owners and end users

http://cfp.mit.edu

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Questions…

- **Gigabit Access: who needs it? For what?**
- **Backhaul transport: faster edges mean what for rest of network?**
- **Video OTT: how different?**
- **Big Data: apps beyond consumer research?**
- **Cloud computing: how does it change network requirements?**
- **Traffic symmetry: what does this mean? Capital investment?**

- **GigaBit Networks**
  - Mobile: complement or substitute?
  - Video: Hollywood redux or user-generated content?
  - Cloud: whose cloud?
  - Future Proofing: fiber is long-lived, lumpy, sunk investment
- **Implications for carrier assets**
  - Last-mile
  - Spectrum
  - Business models and opportunities

Vision of the Broadband Internet Future

Phase 1: 1950-1995
- ➢ Universal telephone service, computing everywhere (in business)
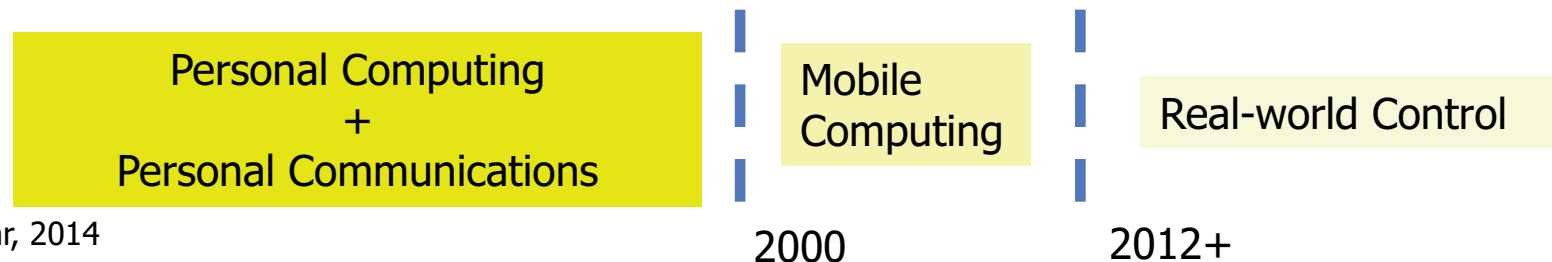- ➢ PCs on every desktop, LANs to tie them together

Phase 2: 1995-2000
- ➢ Internet and mass market data services: computing everywhere in society
- ➢ Mobile telephony and personalization of communications

Phase 3: 2000-2012
- ➢ Broadband: uncork the last-mile speed bottleneck
- ➢ Mobile + Internet convergence
- ➢ Personalization, everywhere/always connected, mixed/multi-media
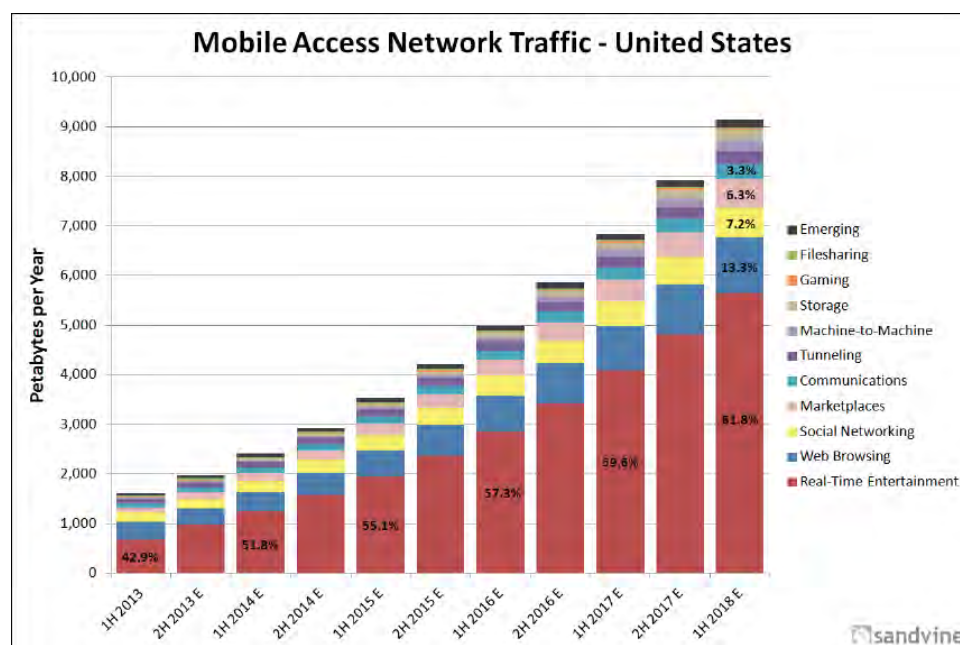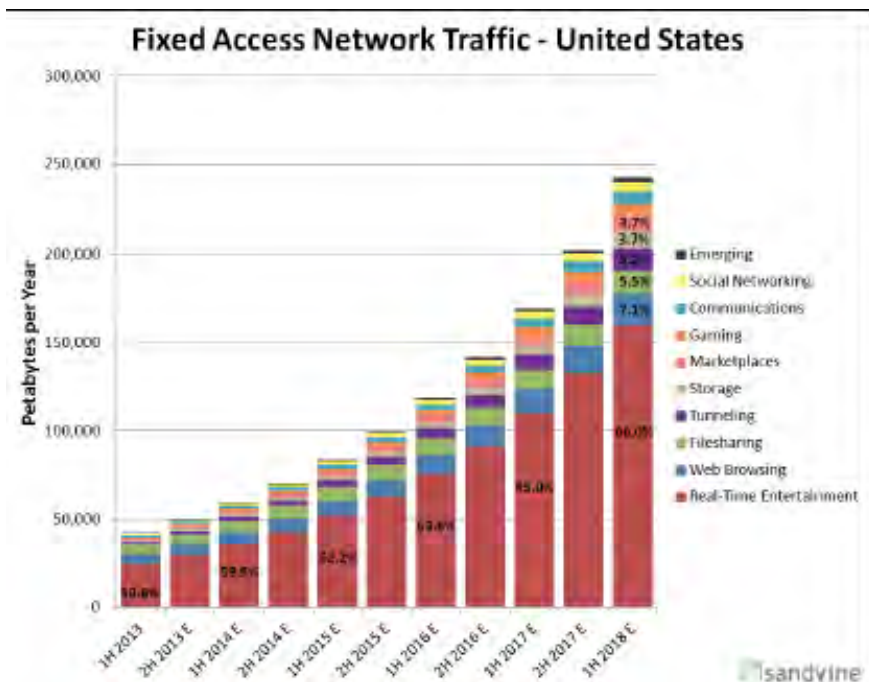- ➢ Social networking, social media

Phase 4(?) : 2013+
- ➢ Big Data : M2M, Sensors, Smart infrastructure/environments
- ➢ Automation and Cyber-mechanical integration
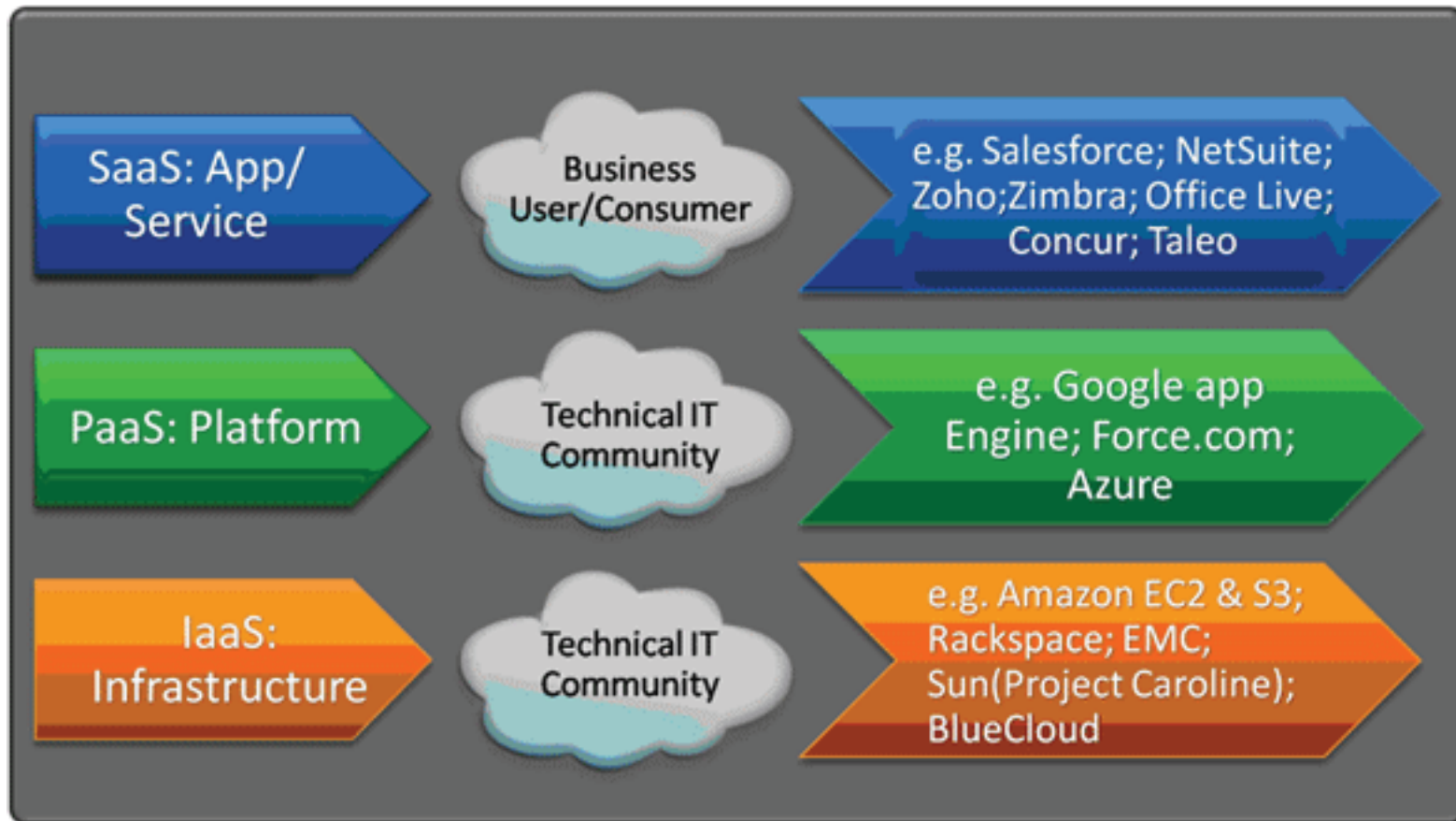- ➢ Cloud computing : connectivity, computing/storage resources, ...

Personal Computing + Personal Communications	Mobile Computing	Real-world Control

2000   2012+

Fixed and Mobile BB Traffic Forecasts

1H2013

Fixed Access Network Traffic - United States

Mobile Access Network Traffic - United States
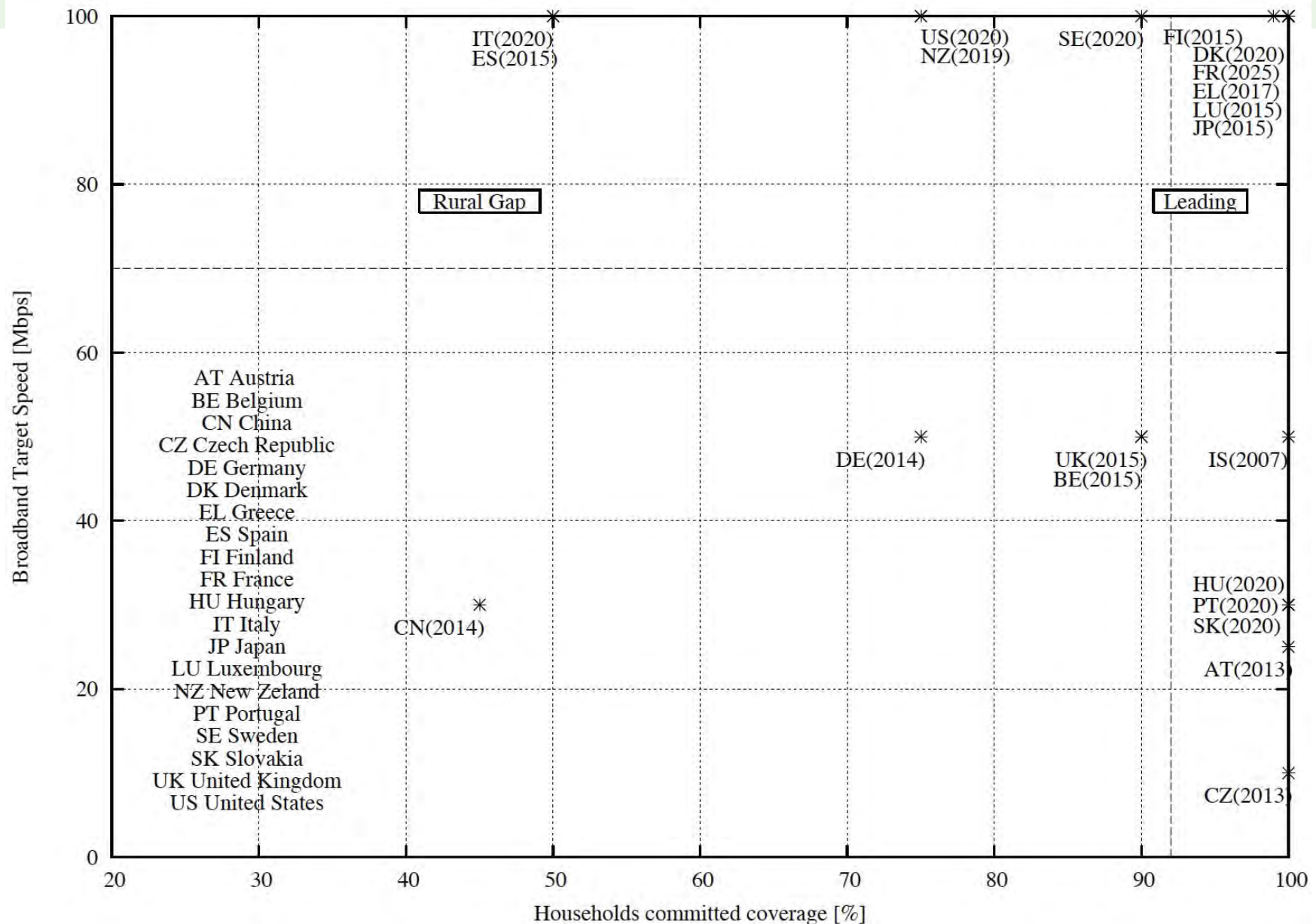
Fixed   50 → 250 EB   Mobile 2 → 9 EB

(~40% CAGR)

-- Real time entertainment 2/3rd data
-- Tunneling to grow
-- Home roaming (current 20%)

© Lehr, 2014

Source:http://www.bsmreview.com/bsm_cloudcomputing.shtml

Broadband Goals : lots with 100Mbps+ NGAN targets !!!

Broadband Target Speed [Mbps] (y-axis)
Households committed coverage [%] (x-axis)

IT(2020)
ES(2015)
US(2020)
NZ(2019)
SE(2020)
FI(2015)
DK(2020)
FR(2025)
EL(2017)
LU(2015)
JP(2015)

Rural Gap

Leading

AT Austria
BE Belgium
CN China
CZ Czech Republic
DE Germany
DK Denmark
EL Greece
ES Spain
FI Finland
FR France
HU Hungary
IT Italy
JP Japan
LU Luxembourg
NZ New Zeland
PT Portugal
SE Sweden
SK Slovakia
UK United Kingdom
US United States

DE(2014)
UK(2015)
BE(2015)
IS(2007)

CN(2014)

HU(2020)
PT(2020)
SK(2020)

AT(2013)

CZ(2013)

data

MOST ENTERPRISES TODAY GENERATE MORE DATA THAN THEY CAN PROCESS

SEQUENCING DATABASES

MEASUREMENTS

SENSORS
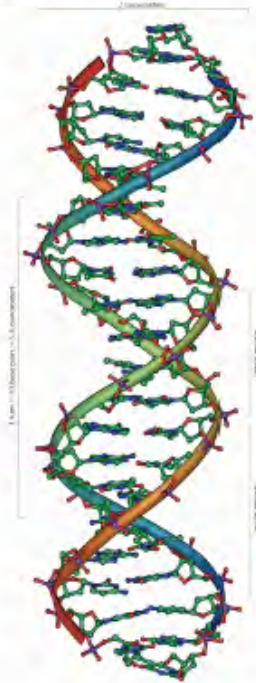
CLICK STREAMS

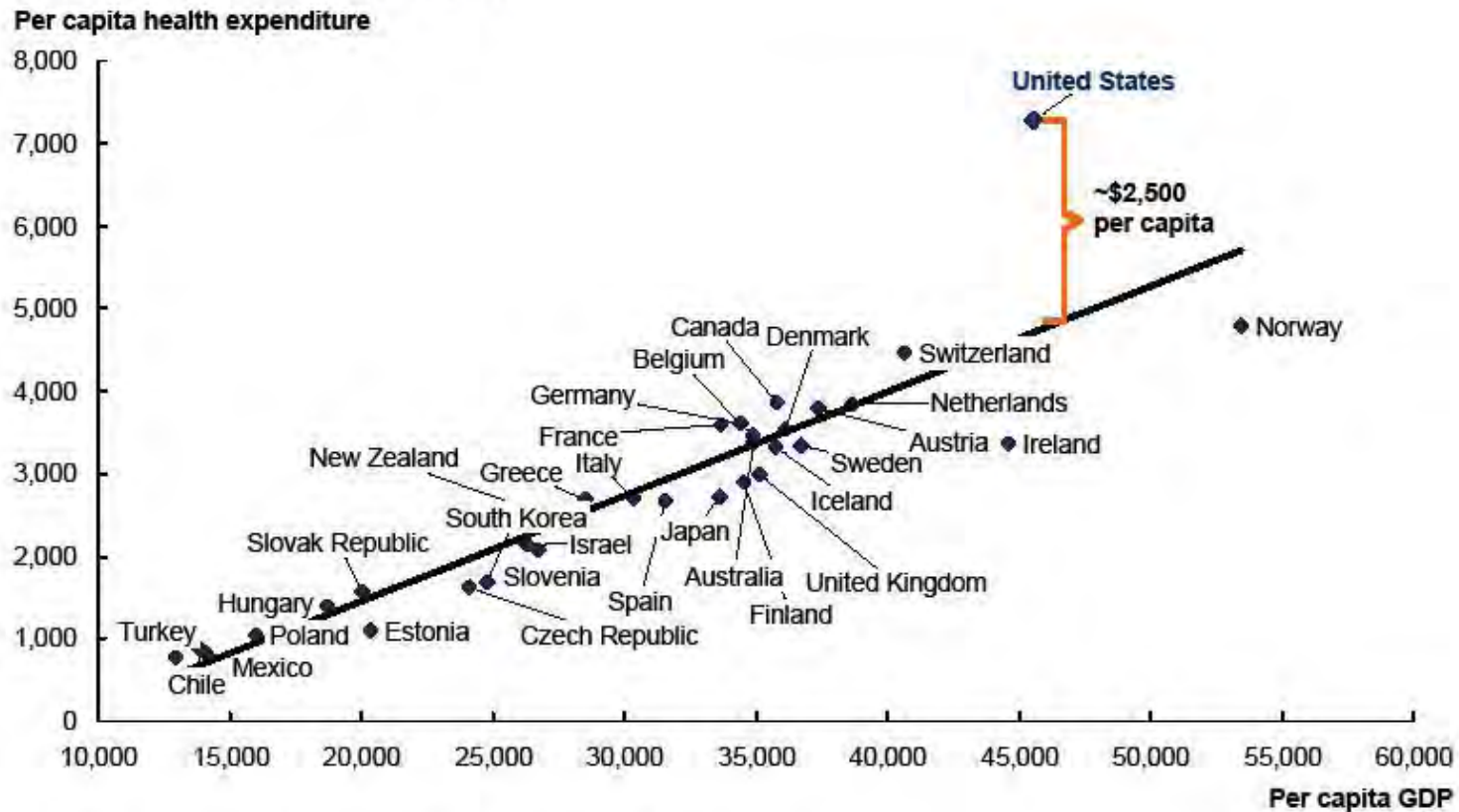CREDIT CARD TRANSACTIONS

Bank Name

1234 5678 9876 5432

CARDHOLDER

scienceray.com

...AND THE AMOUNT OF DATA IS GROWING AT 50% PER YEAR

- according to IDC

A comparison with OECD countries suggests that the total economic potential for efficiency improvements is about $750 billion

Per capita health expenditure and per capita GDP, OECD countries, 2007
$ purchasing power parity (PPP)

SOURCE: Organisation for Economic Co-operation and Development (OECD)

Source: McKinsey (2011), "Big Data: the next frontier for innovation, competition, and productivity"

The Internet of Things