– alpha

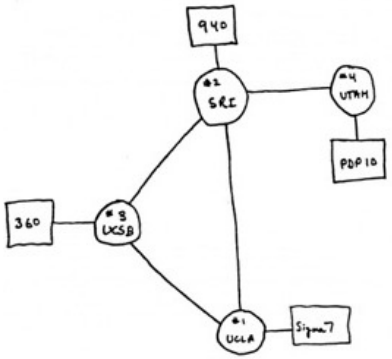
The Edge: Evolution or Revolution?

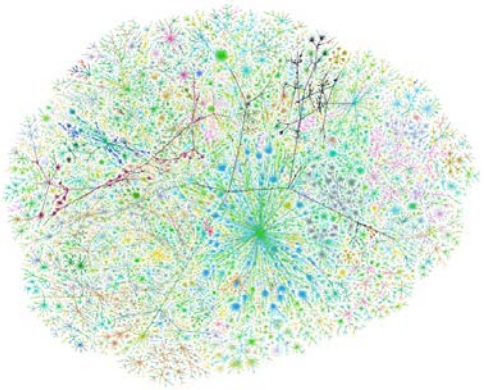
Pablo Rodriguez, CEO

alpha.company

October 2017
ACM SEC, Symposium on Edge Computing
San Jose, California

Internet Design

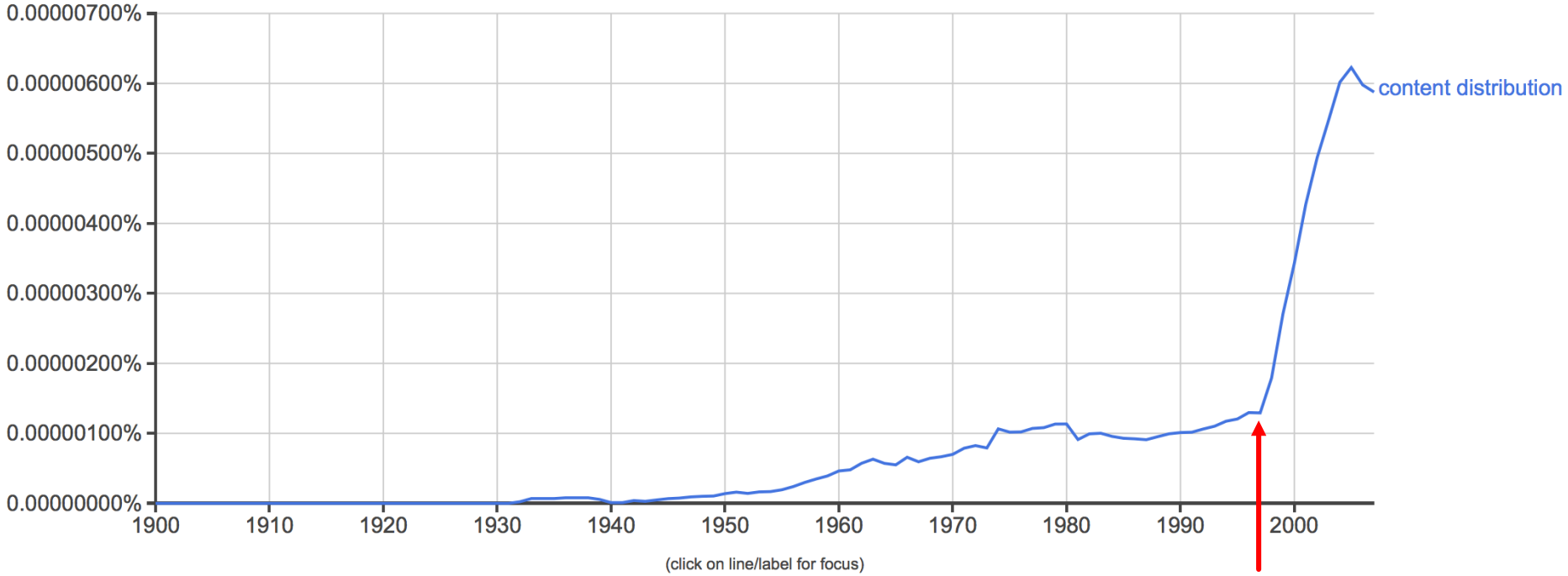




Lacked:

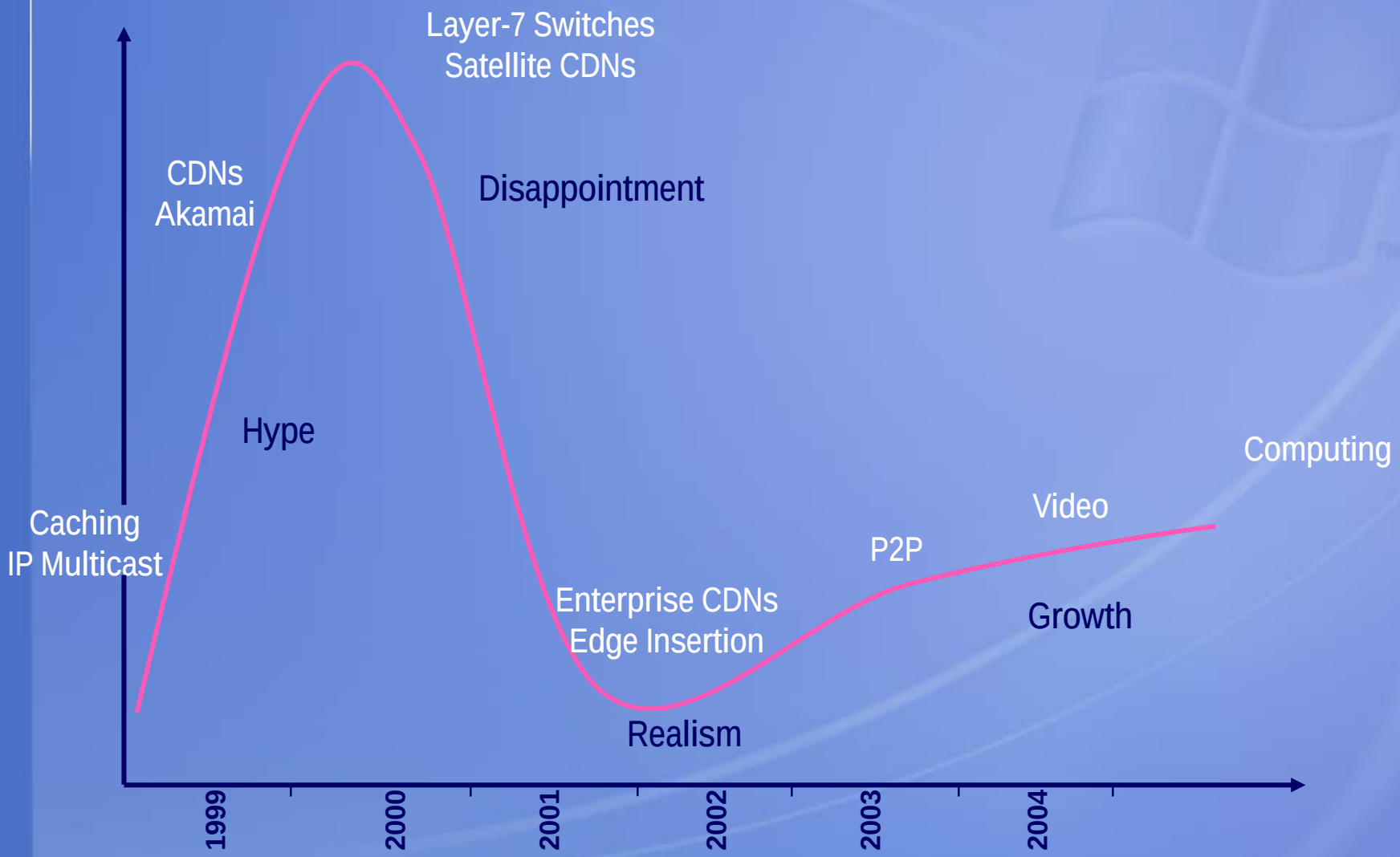
- Mobilty
- Security & Privacy
- Economics
  - Sense that the Internet was free
- Content Distribution

2



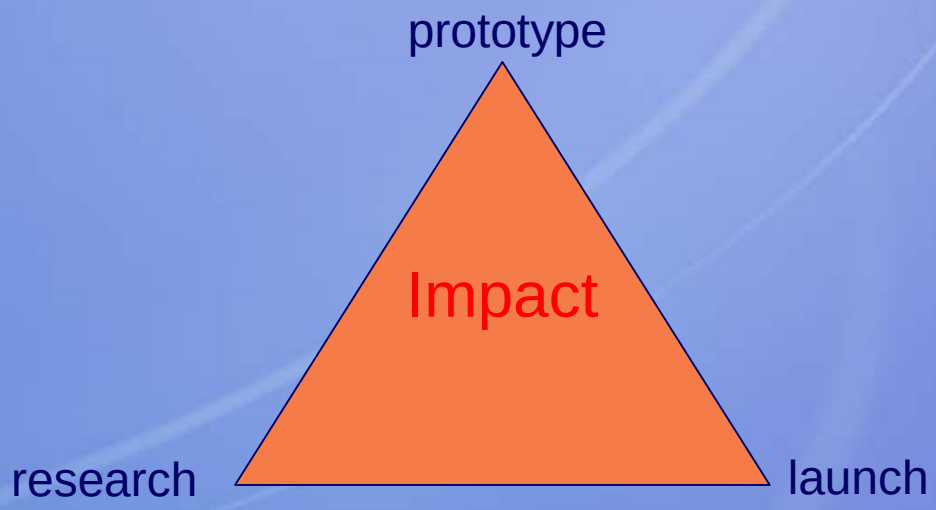
P. Rodriguez, “Scalable Content Distribution in the Internet”, Ph.D. Thesis, EPFL 1997-2000

Overlays Evolution



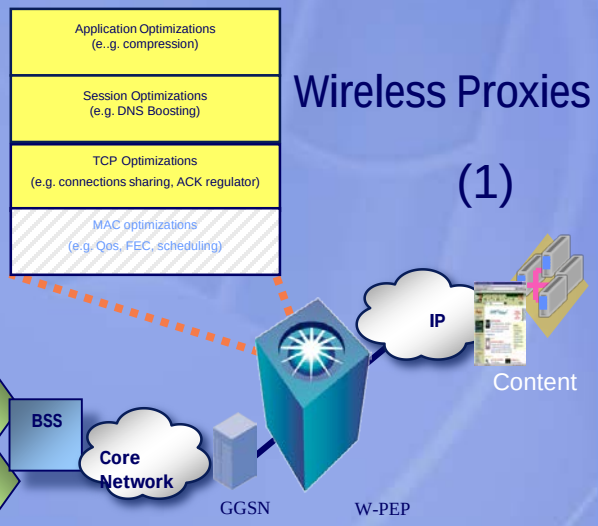
My Upbringing

- EPFL/Eurecom
- Inktomi, Adquired by Yahoo!
- Netli, now part of Akamai
- Tahoe Networks, now part of Nokia
- Bell-Labs
- Microsoft Research
- Telefonica



Three Edge Example projects

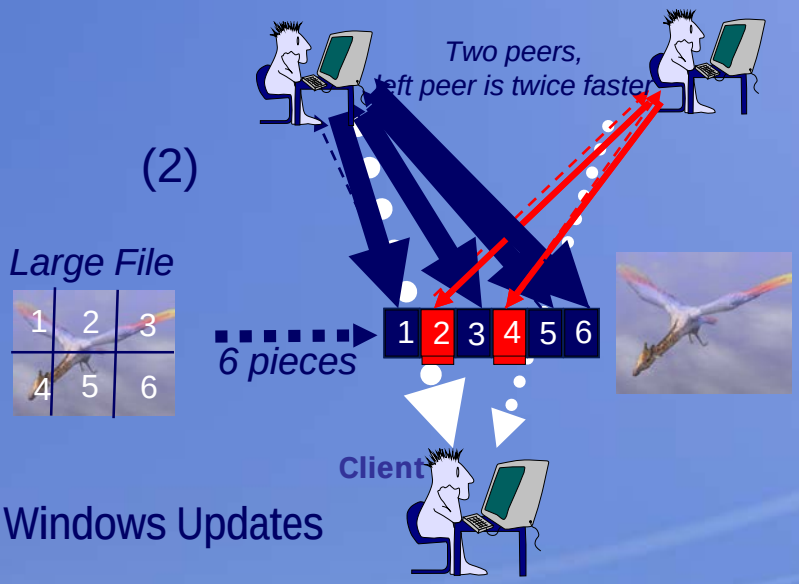
- 1. Wireless Proxies (Bell Labs)
- 2. P2P Content Distribution (MSFT)
- 3. Video CDN (Telefonica)



Wireless Proxies

(1)

(2)



Windows Updates

(3)

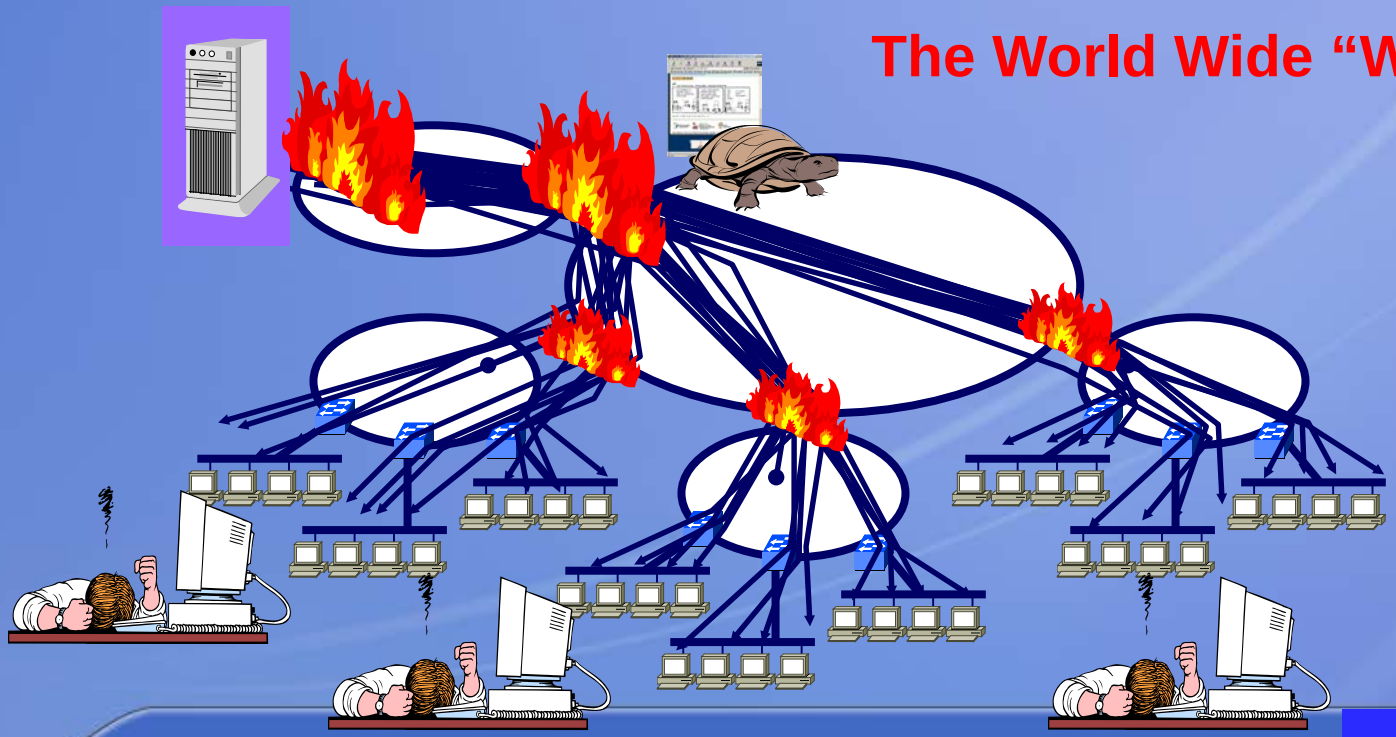
Telefonica Video CDN

1 Back to the Future

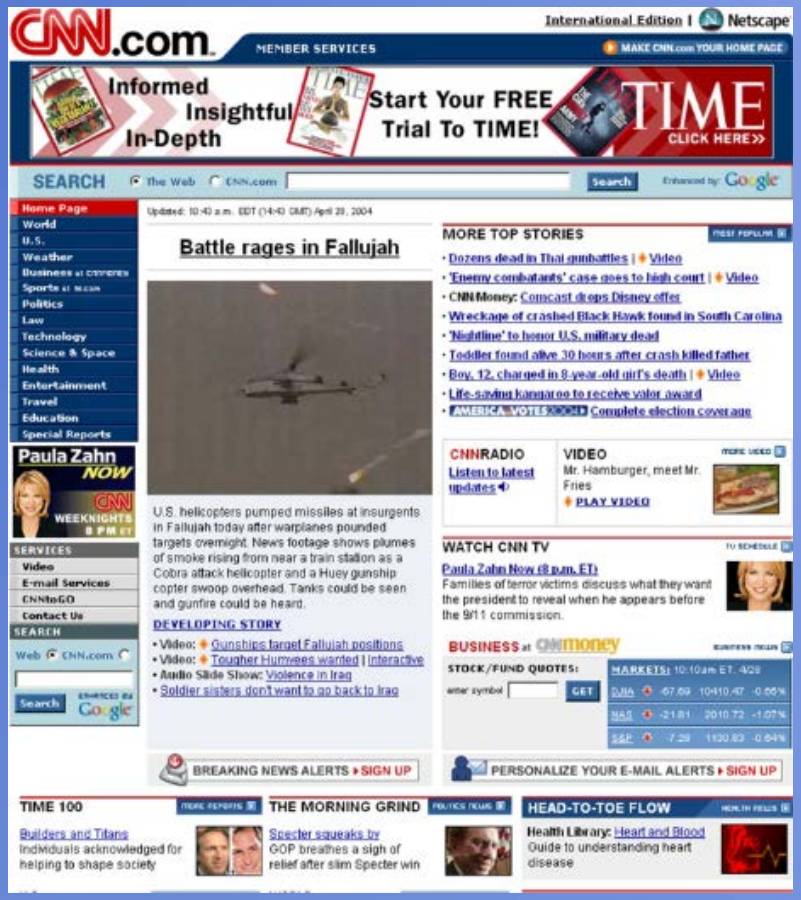
The Problem

- The Internet has been growing very fast, both in the number of users and in the available content
  - Overloaded servers and network links.
  - Frustrated users.

“The Web can kill the Internet”, B. Metcalfe 1995

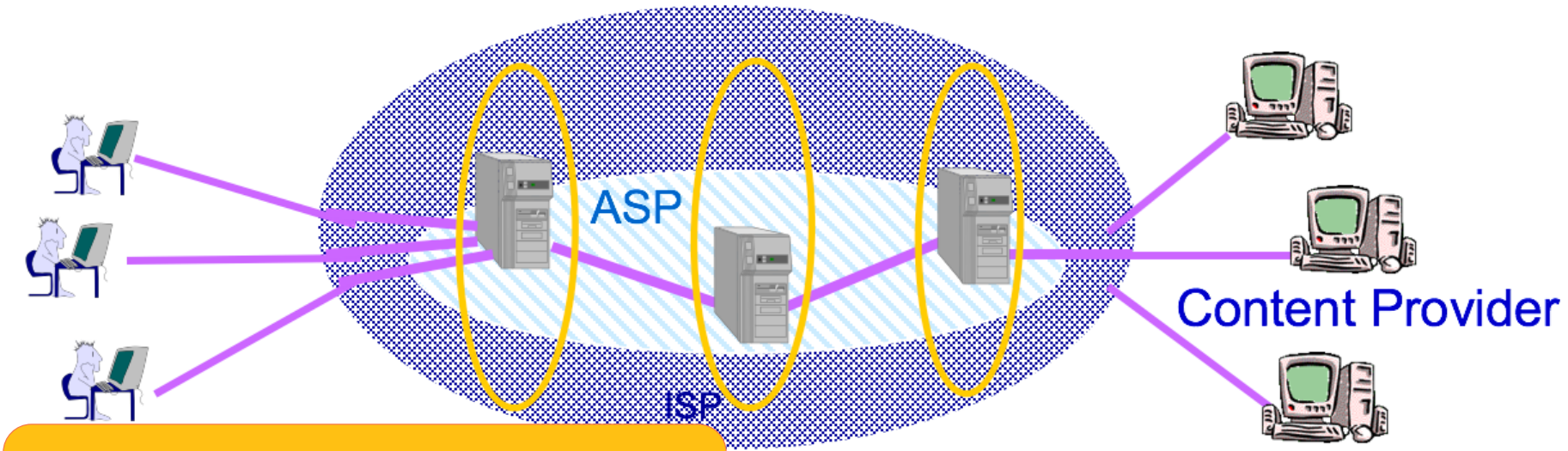


Not ready for Flash-Crowd Events



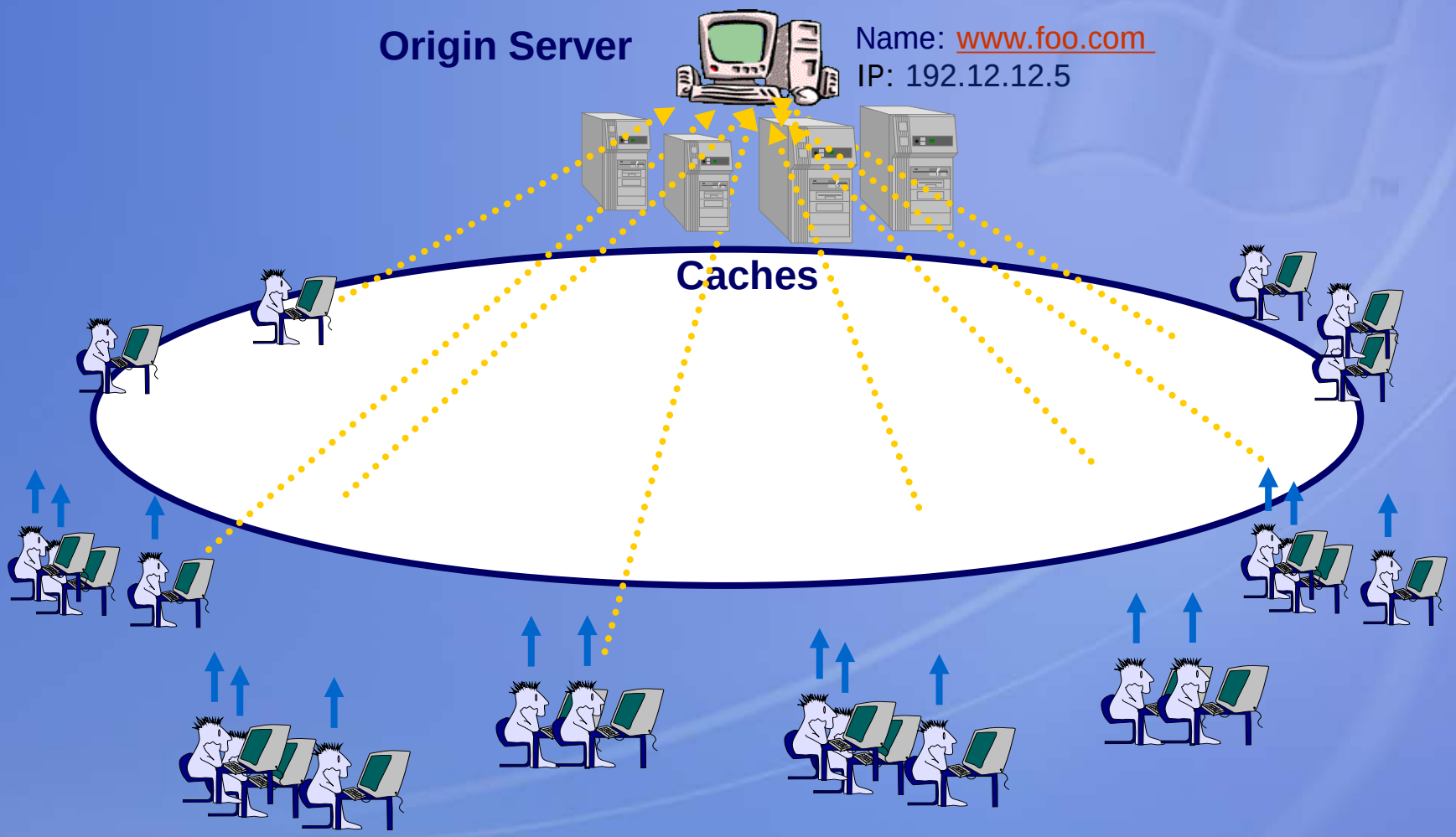
Application Service Providers: ASPs

- An ASP is an overlaid network of nodes that allows the efficient and fast transmission of Web applications to a large receiver population
- ASPs tightly cooperate with content providers

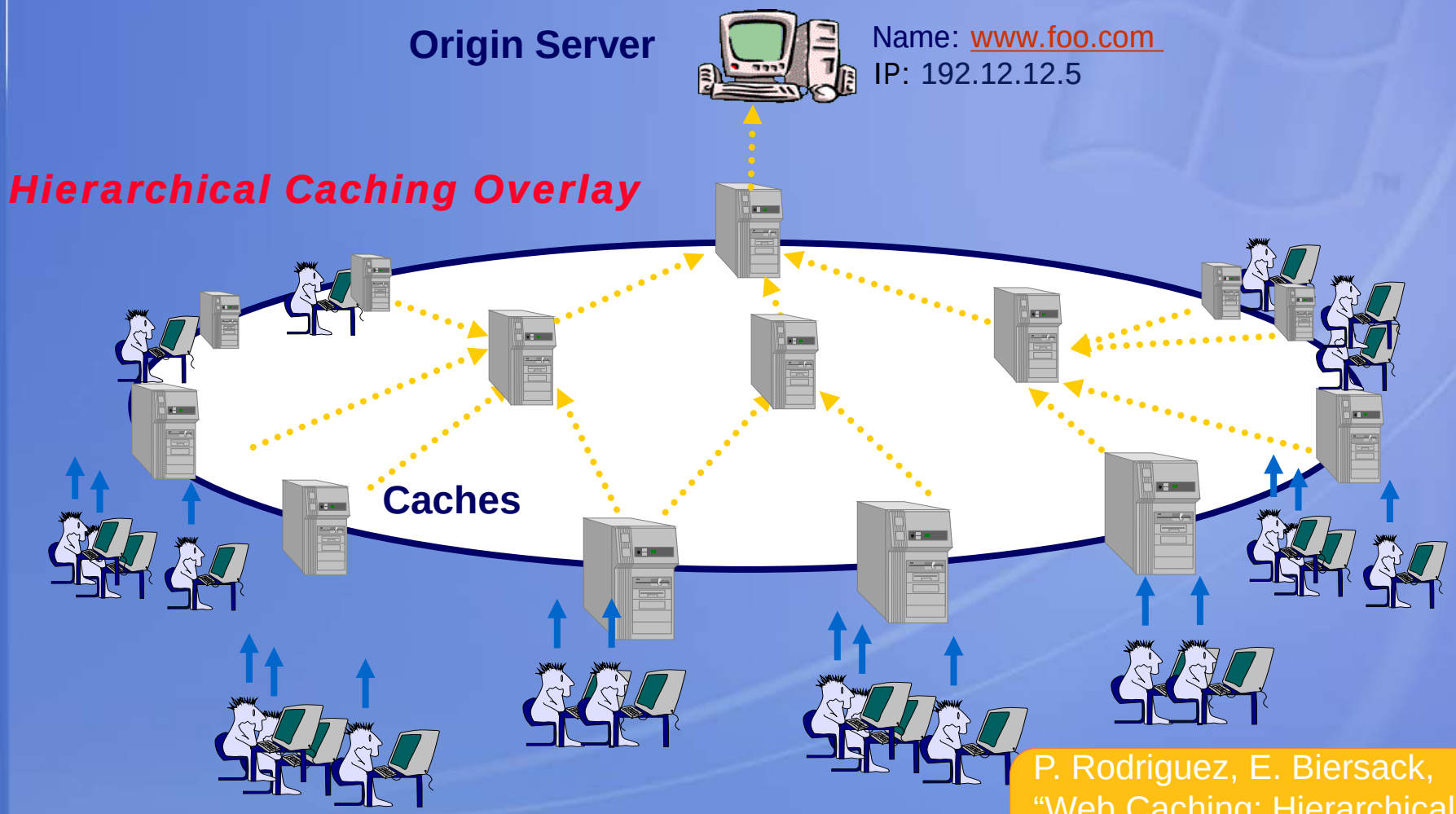


P. Rodriguez, “Scalable Content Distribution in the Internet”, Ph.D. Thesis, EPFL 1996-2000

Centralized



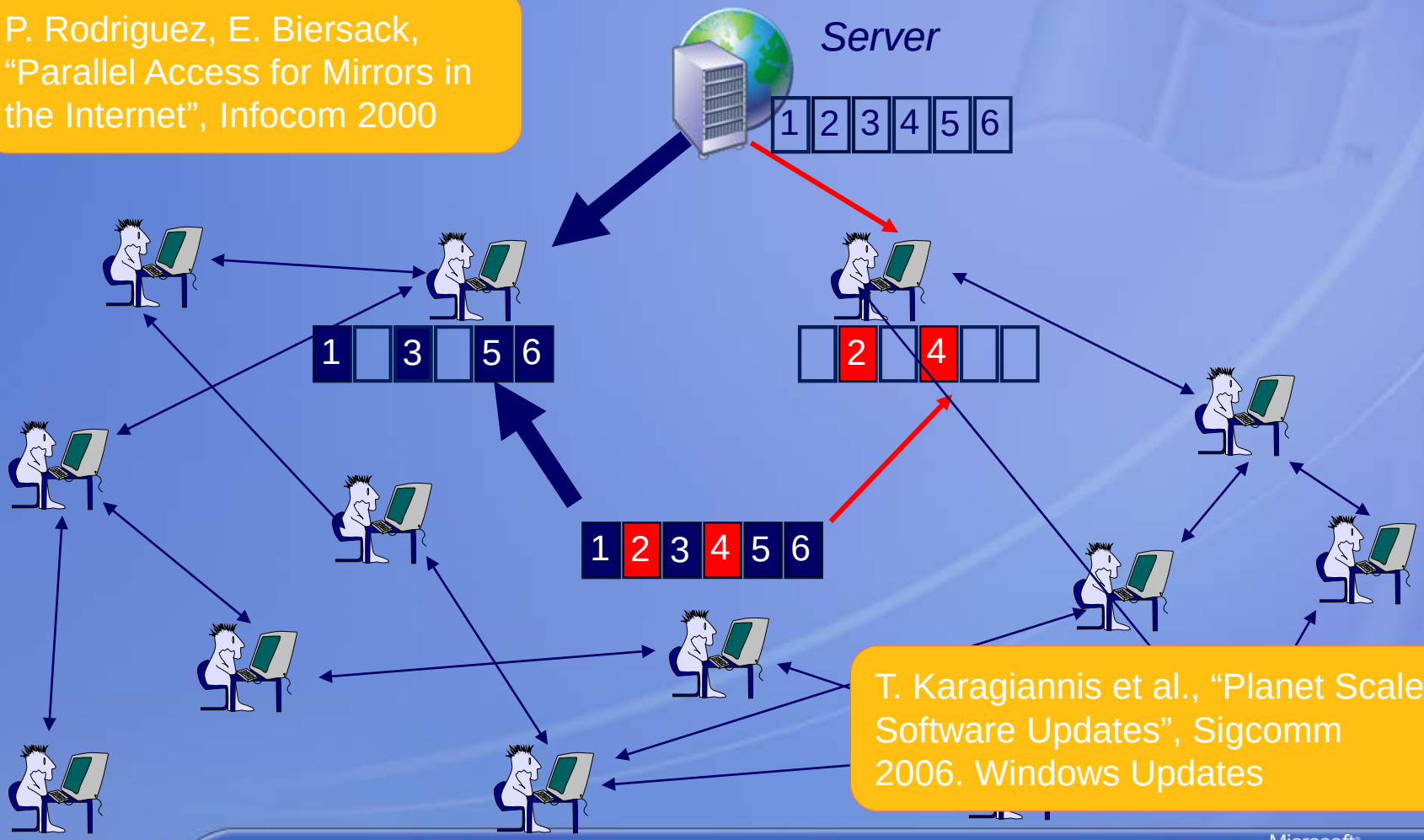
Hierarchical



P. Rodriguez, E. Biersack, "Web Caching: Hierarchical vs Distributed Caching", IEEE/ToN 1999

P2P File Distribution

P. Rodriguez, E. Biersack, “Parallel Access for Mirrors in the Internet”, Infocom 2000



T. Karagiannis et al., “Planet Scale Software Updates”, Sigcomm 2006. Windows Updates

Microsoft Research Cambridge

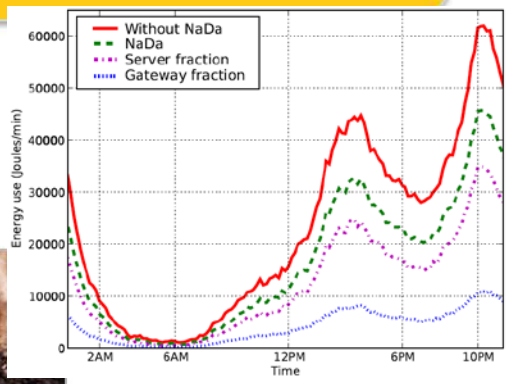
Nano Data Centers

A set-top-box provides

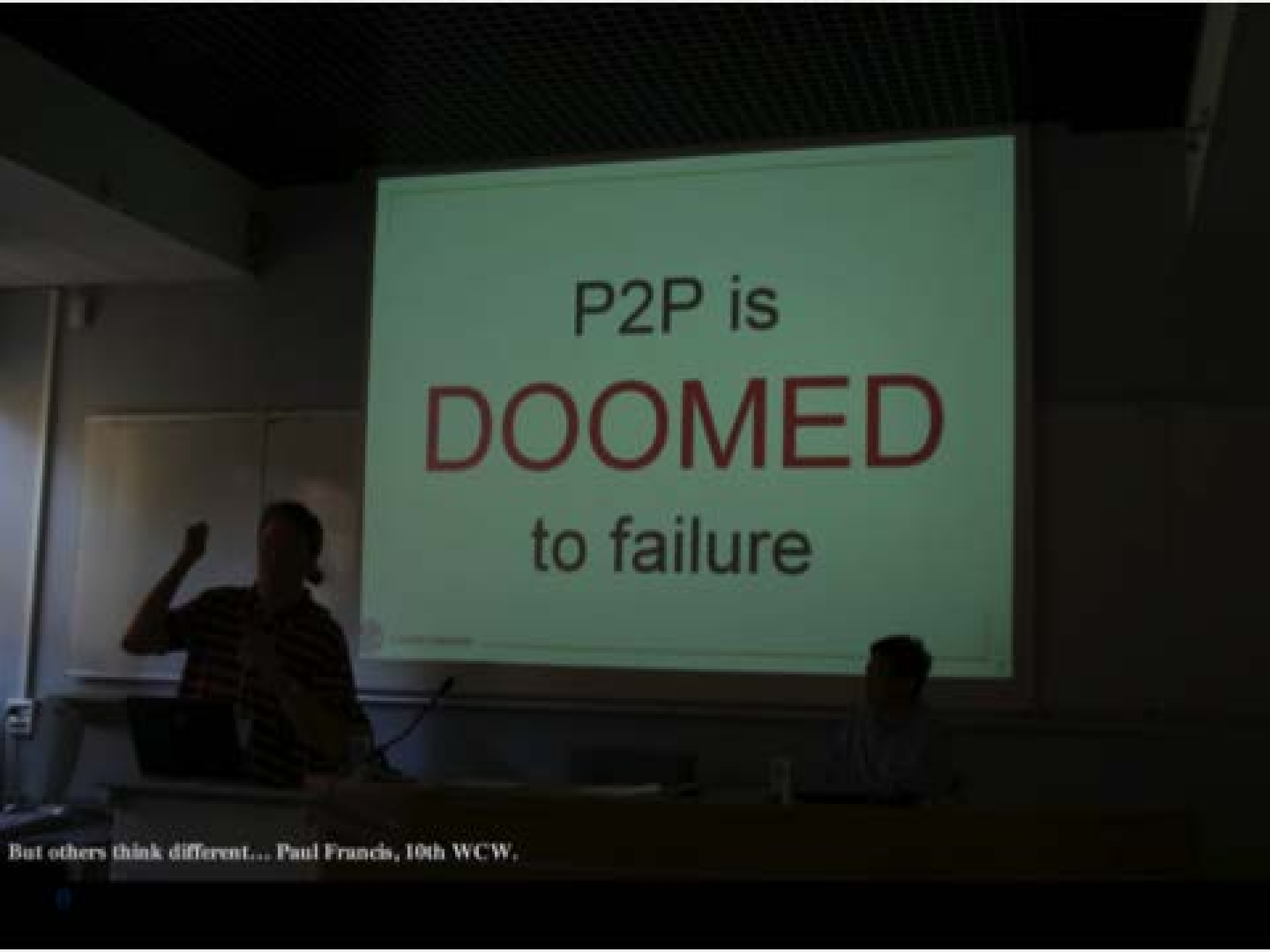
- cheaper power & cooling
- decent CPU & storage
- predictable behaviour
- central control

… all we need to do is organize them a bit!

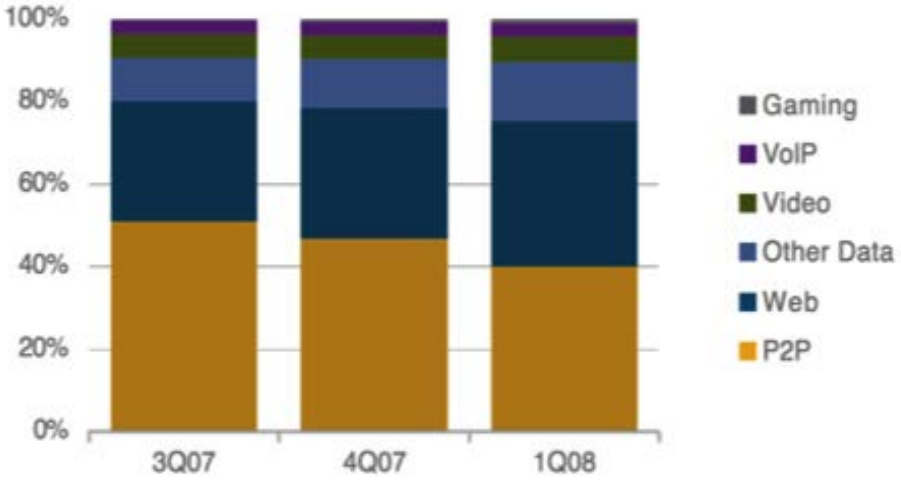
"Greening the Internet with Nano Data Centers," V. Valancius, N. Laoutaris, L. Massoulie, C. Diot, P. Rodriguez, in Proc. of ACM/CoNEXT'09



Home Edge Cloud functionality

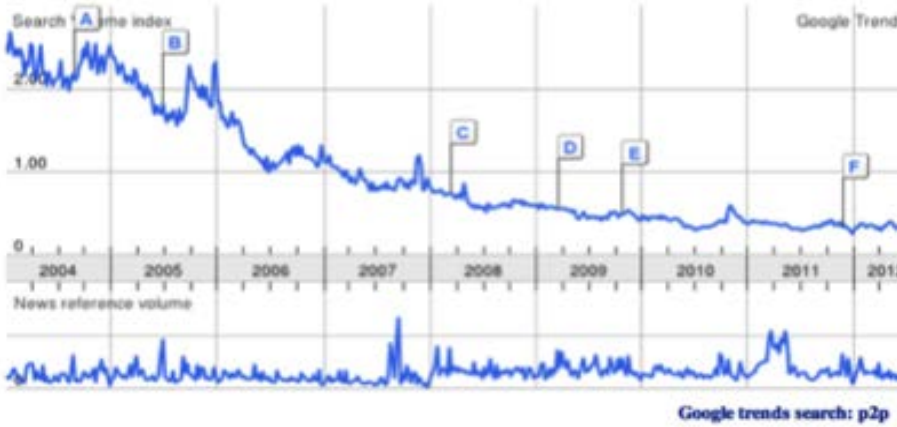


But others think different… Paul Francis, 10th WCW.



In the long run it is cheaper and easier to use Cloud computing and core networks to do Content Distribution rather than P2P

P2P Success...?



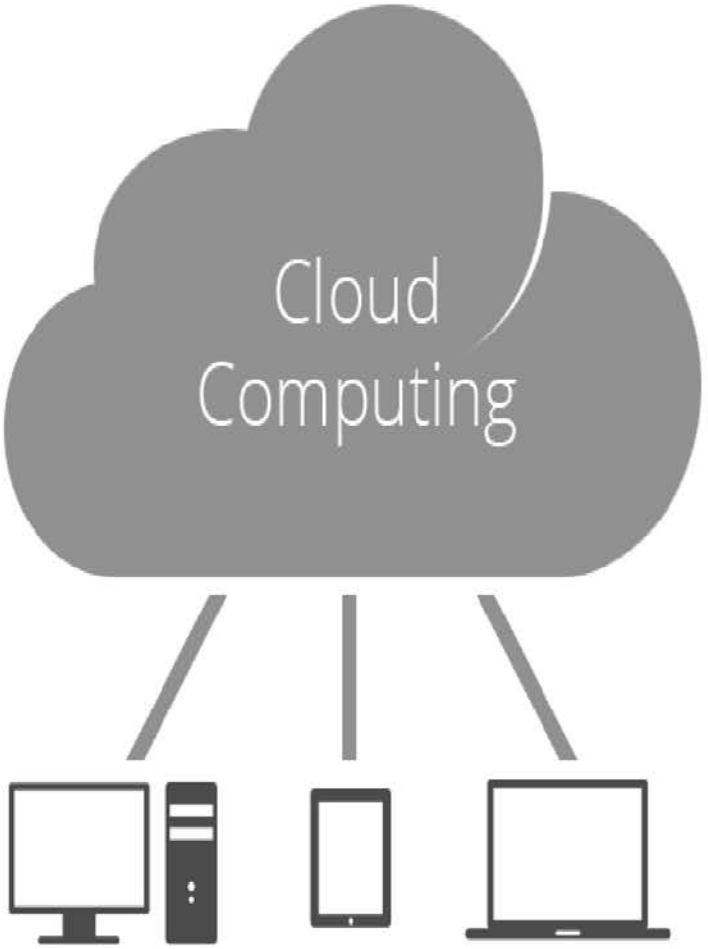
Google trends search: p2p

Today's world is centralized in the cloud

Cloud Computing, the long-held dream of computing as a utility, transformed a large part of the IT industry.

Instead of purchasing applications and installing them onto a computer, **cloud computing allows to lease the applications on demand and access them over the internet**.

- Adaptive subscription based model. Pay for what you use. SaaS, PaaS, IaaS,...
- Homogeneous workloads could seamlessly and cost-efficiently be used on commodity hardware
- Impacting performance with higher VM densities
- Costs and flexibility of use as the main drivers. Tap on the utility computing model using economies of scale.



A

Negotiating premium peering prices: A quantitative model with applications

Costas Courcoubetis, Singapore University of Technology and Design
Laszlo Gyarmati, Qatar Computing Research Institute
Nikolaos Laoutaris, Telefonica Research and Development
Pablo Rodriguez, Telefonica Research and Development
Kostas Sdrolias, Athens University of Economics and Business

We have developed a novel methodology for deriving bandwidth prices for premium direct peering between Access ISPs (A-ISPs) and Content and Service Providers (CSPs) that want to deliver content and services in premium quality. Our methodology establishes a direct link between service profitability, *e.g.*, from advertising, user- and subscriber-loyalty, interconnection costs, and finally bandwidth price for peering. Unlike existing work in both the networking and economics literature, our resulting computational model, built around Nash bargaining, can be used for deriving quantitative results comparable to actual market prices. We analyze the US market and derive prices for video, that compare favorably with existing prices for transit and paid peering. We also observe that the fair prices returned by the model for high-profit/low-volume services such as search, are orders of magnitude higher than current bandwidth prices. This implies that resolving existing (fierce) interconnection tussles may require per service, instead of wholesale, peering between A-ISPs and CSPs. Our model can be used for deriving initial benchmark prices for such negotiations.

Categories and Subject Descriptors: 500 [**Networks**]: Network economics

General Terms: Economics, Experimentation, Measurement

Additional Key Words and Phrases: Interconnection economics, pricing, premium service delivery, tussle analysis

ACM Reference Format:
Costas Courcoubetis, Laszlo Gyarmati, Nikolaos Laoutaris, Pablo Rodriguez, Kostas Sdrolias, 2016. Negotiating premium peering prices: A quantitative model with applications. *ACM Trans. Internet Technol.* V, N, Article A (January YYYY), 21 pages.
DOI: http://dx.doi.org/10.1145/0000000.0000000

1. INTRODUCTION

There are many "tussles" [Clark et al. 2005] affecting the Internet, ranging across regulation, privacy, network interconnection, and pricing. The economics of peering [Norton 2012], is among the thorniest, but yet, least understood ones. The term peering refers to the interconnection between networks for the purpose of exchanging traffic directly between them. Classic *unpaid peering* played a crucial role in the evolution of

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DOI: http://dx.doi.org/10.1145/0000000.0000000

Network Neutrality

A COMPUTER WANTED.

WASHINGTON, May 1.—A civil service examination will be held May 18 in Washington, and, if necessary, in other cities, to secure eligibles for the position of computer in the Nautical Almanac Office, where two vacancies exist—one at $1,000, the other at $1,400.

The examination will include the subjects of algebra, geometry, trigonometry, and astronomy. Application blanks may be obtained of the United States Civil Service Commission.

The New York Times
Published: May 2, 1892
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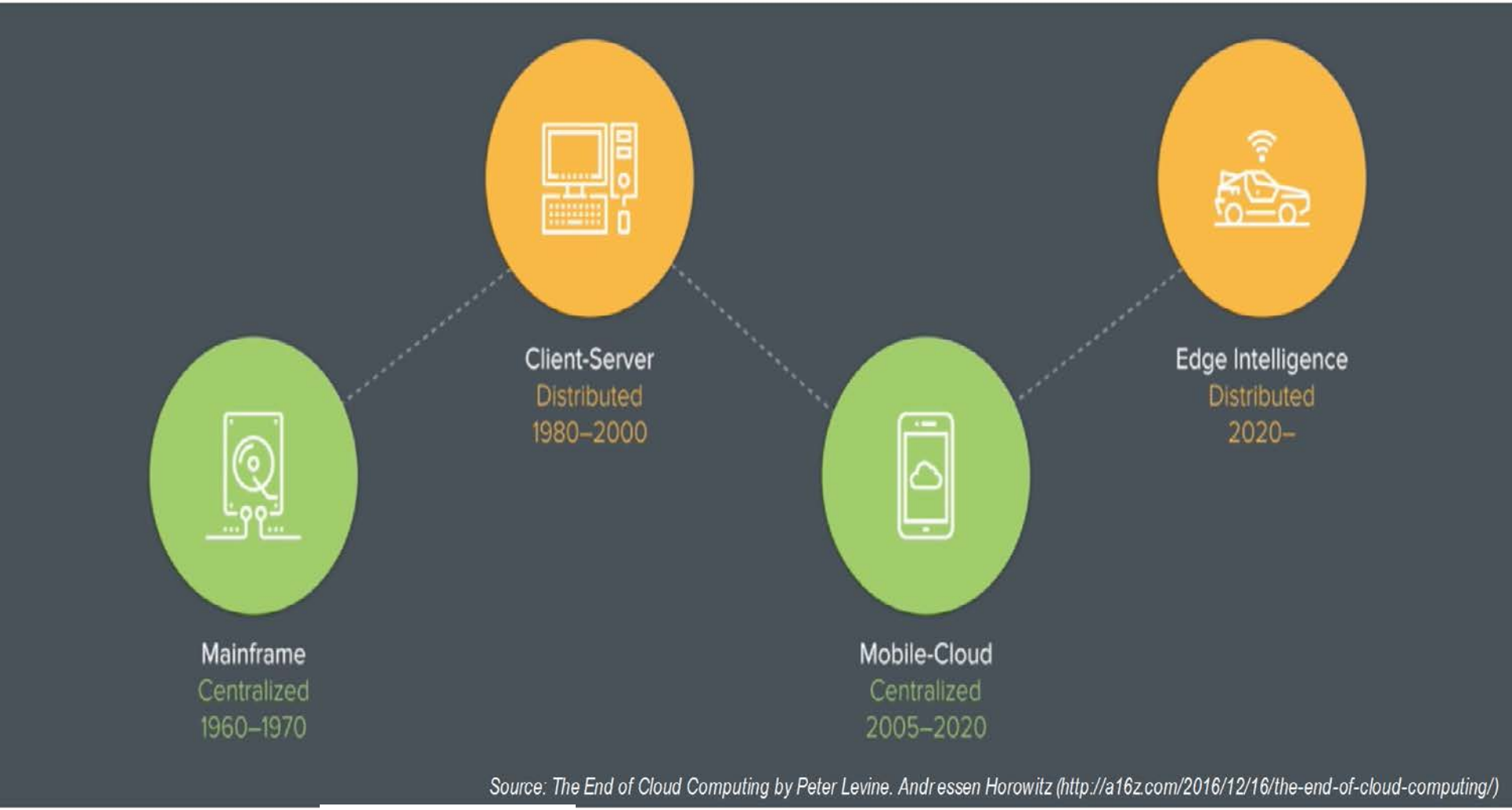
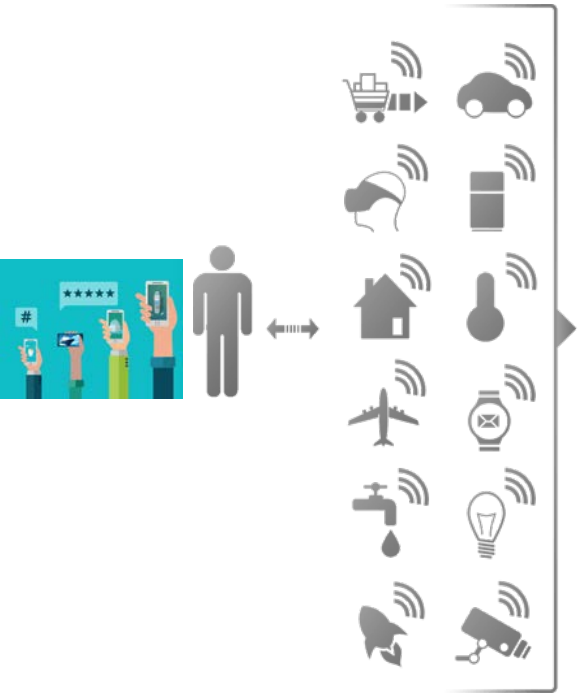
Don't act so surprised. It's just back to the future.



Source: The End of Cloud Computing by Peter Levine. Andr essen Horowitz (http://a16z.com/2016/12/16/the-end-of-cloud-computing/)

IoT objects become more and more sophisticated



UGC → IoT

Connected devices have never collected **so much data about their environment** (vision, location, temperature...).

That **real-world data is massive** (e.g. a self-driving car generates about 10 gigabytes per mile).

Pushing it back to the cloud will become increasingly difficult. **Existing infrastructures will not be able to handle its volume**.

1. An enormous amount of data is already being generated

Autonomous Car

10 Gb / mile

Lytro Cinema VR

400 Gb / sec

Two trends that will disrupt the cloud paradigm

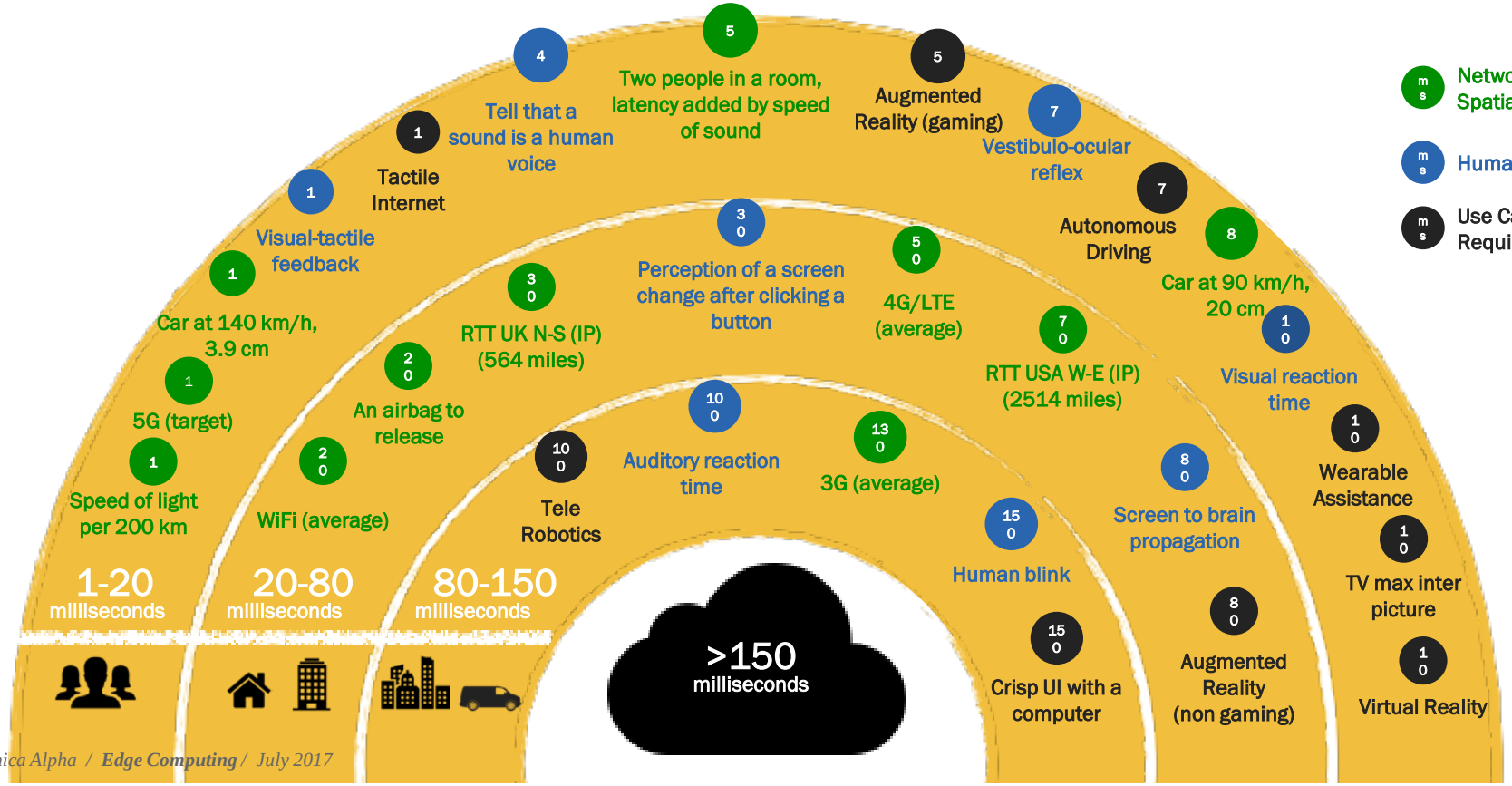
Increasing data

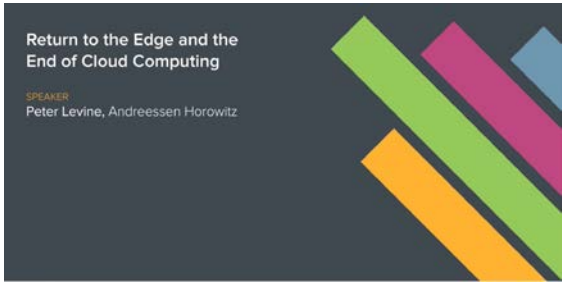
Real-time needs

How many Edges?

THE ADVENT OF EDGE COMPUTING

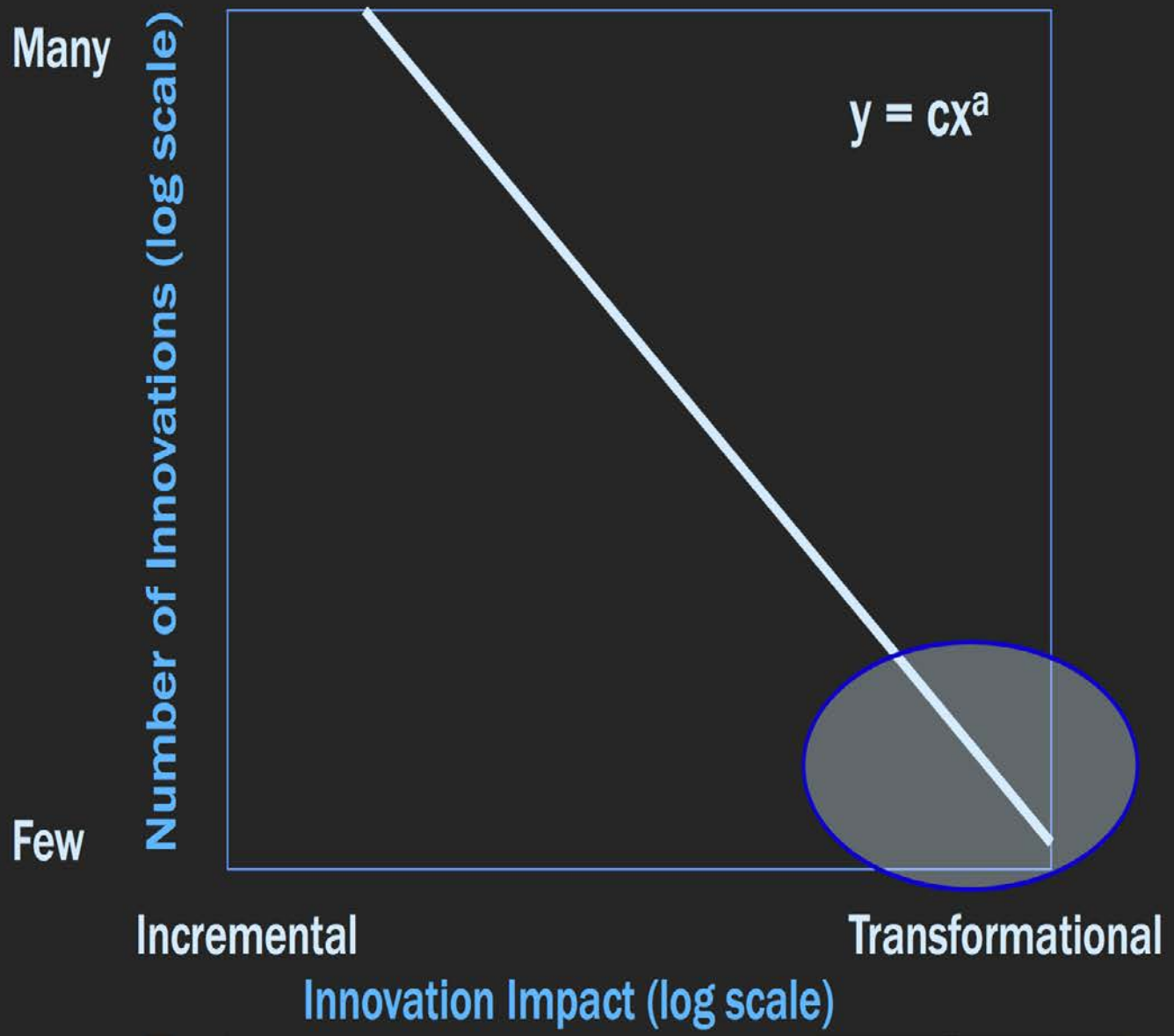
Many edges, per use case and workload




Return to the Edge and the
End of Cloud Computing
SPEAKER
Peter Levine, Andreessen Horowitz

agement,...).

power law of transformational innovation



transformational innovation drives growth

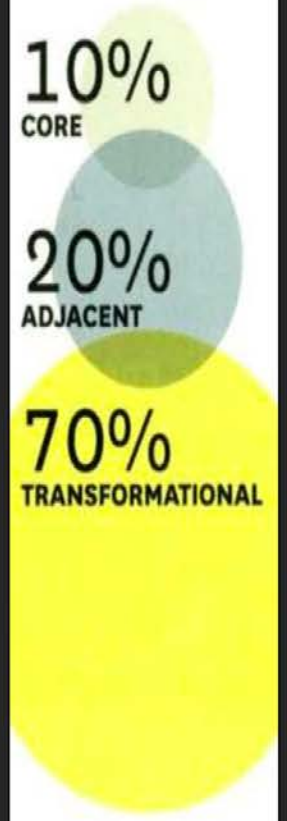
IS THERE A GOLDEN RATIO?

Analysis reveals that the allocation of resources shown below correlates with meaningfully higher share price performance. For most companies, this breakdown is a good starting point for discussion.

Innovation Ambition Matrix
Harvard Business Review, May 2012

HOW INNOVATION PAYS THE BILLS

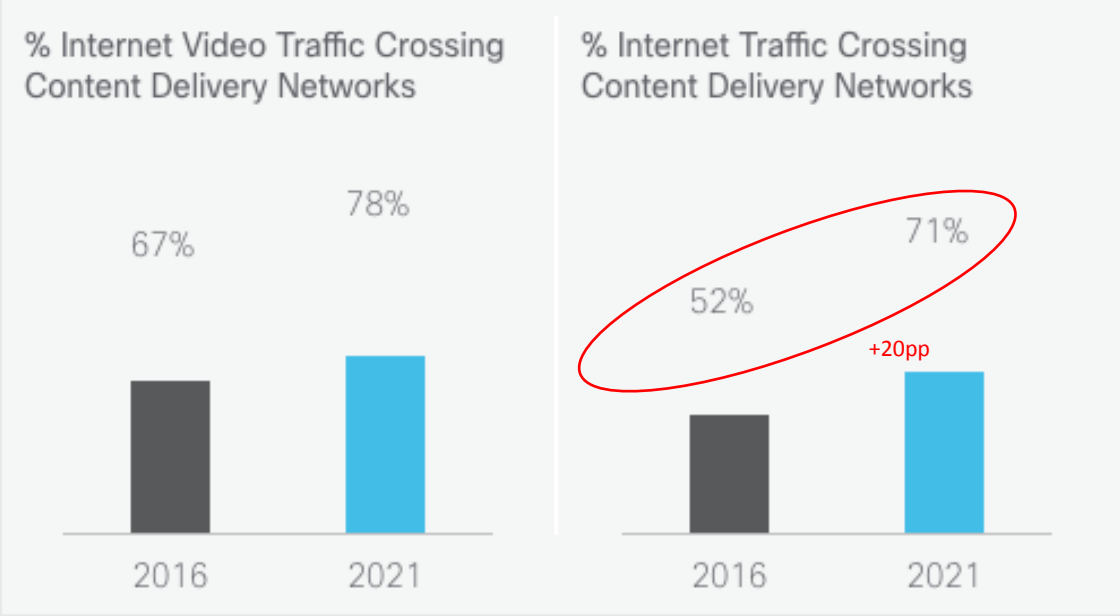
Among high performers that invest in all three levels of innovation, we find the following distribution of total returns. As it happens, this ratio is the inverse of the resource allocation ratio we discovered in high-performing companies.



Incremental Edge Computing Examples

Evolution of Video traffic (Global)

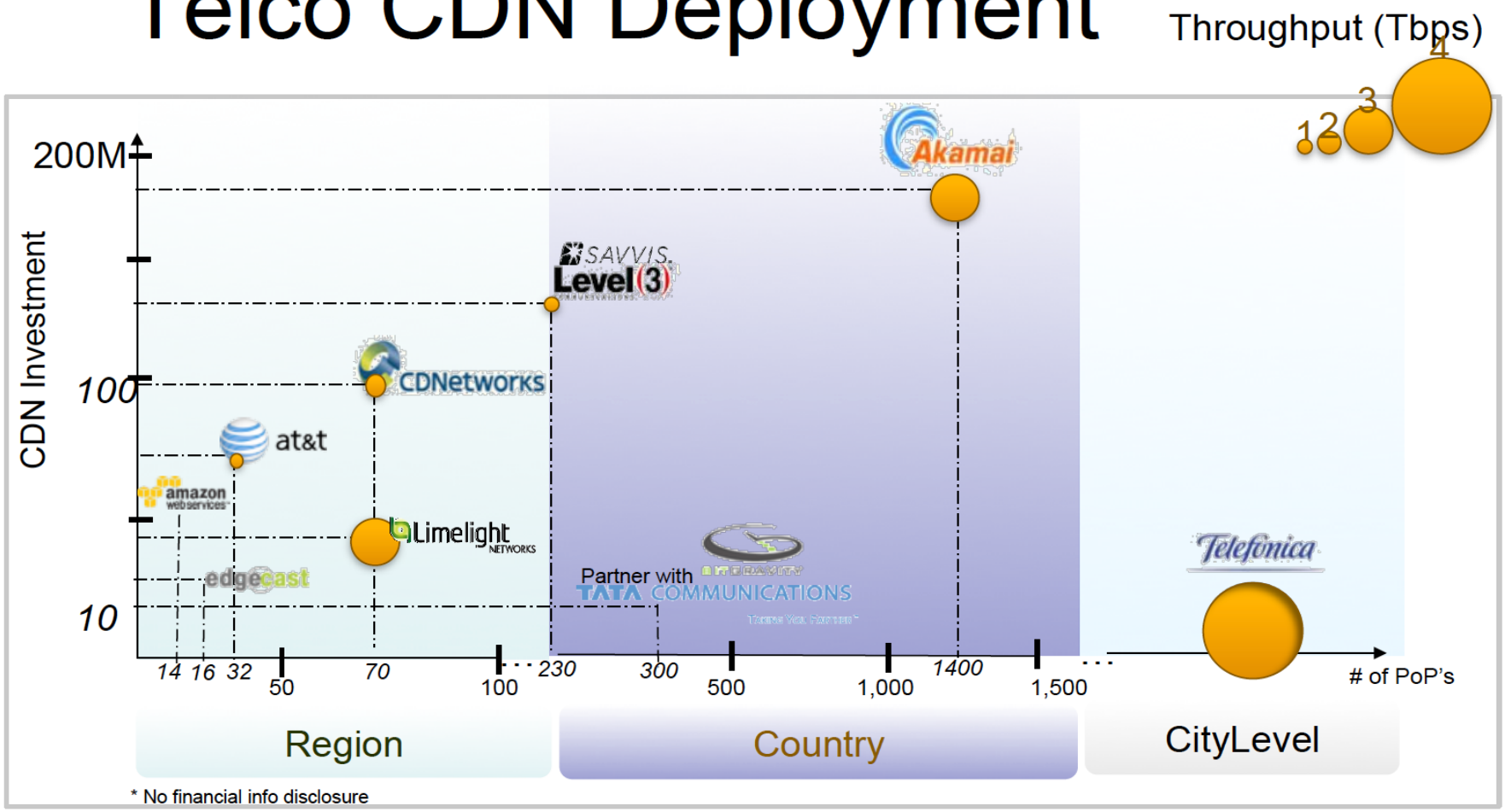
CDNized content will grow to 70% globally



Peak Internet traffic will grow at a compound annual growth rate of 35% from 2016 to 2021, compared to 26% for average Internet traffic.

Virtual CDNs at the EDGE

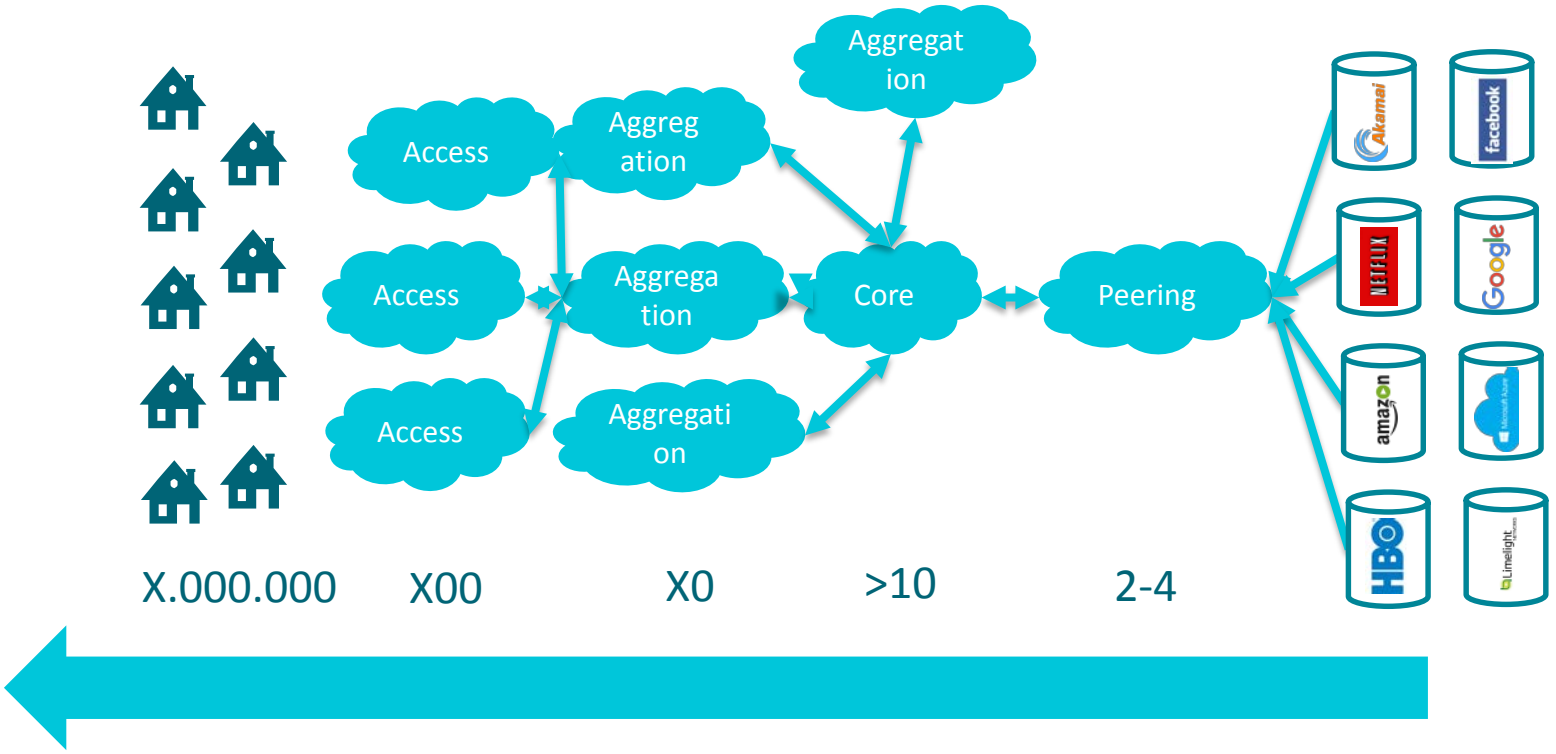
Telco CDN Deployment



With a much lower investment, Telcos can deploy CDNs with much deeper granularity

Source: companies K-10 of 2008 and Investments press Released
Where Level 3 = Savvis Infrastructure + companies Pops
CDNetworks (Korea) bought Panther (USA) and is know as the 3rd in MS

CDNs Today…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Core
Peering
Access
Aggregati on
Akamai
facebook
NETFLIX
Google
amazon
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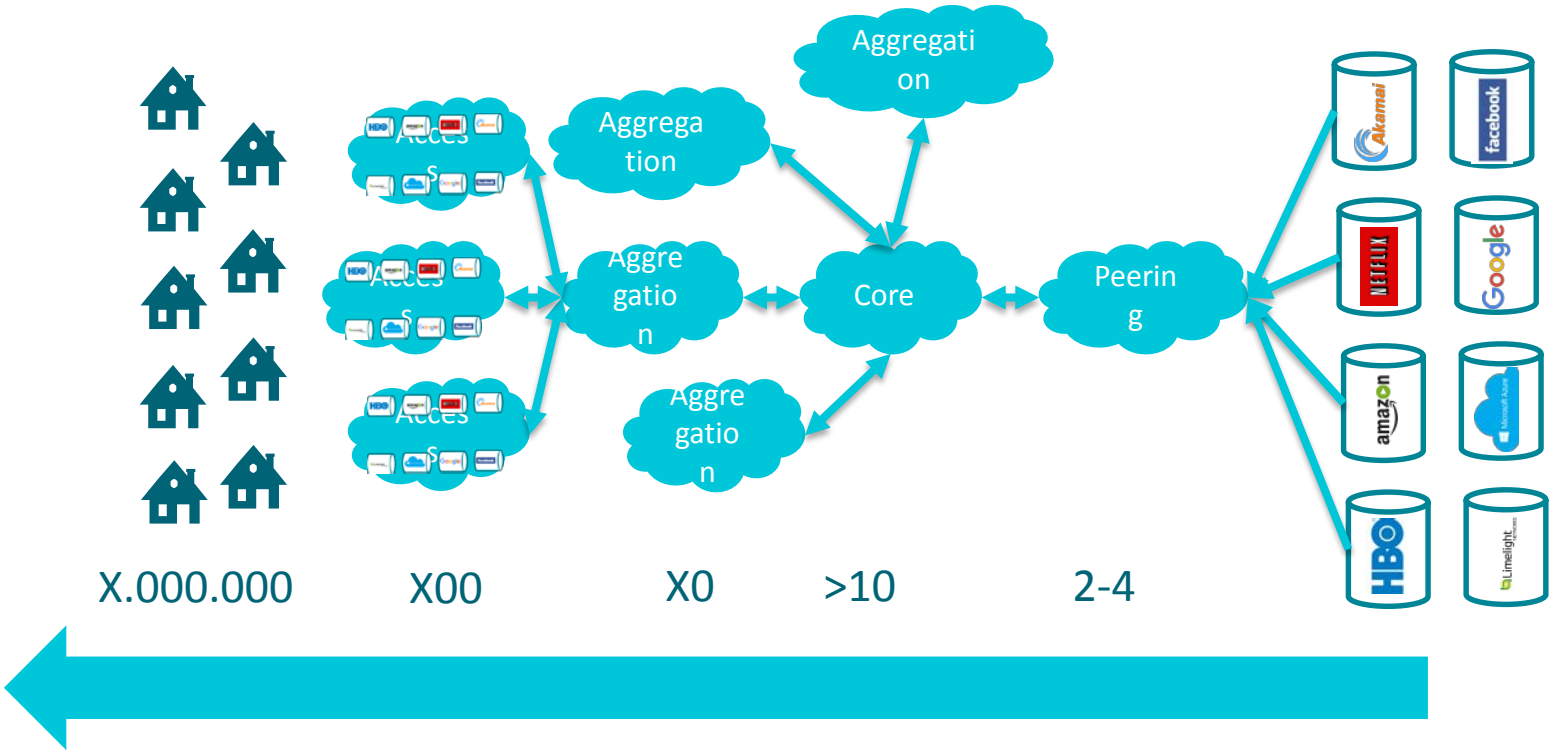
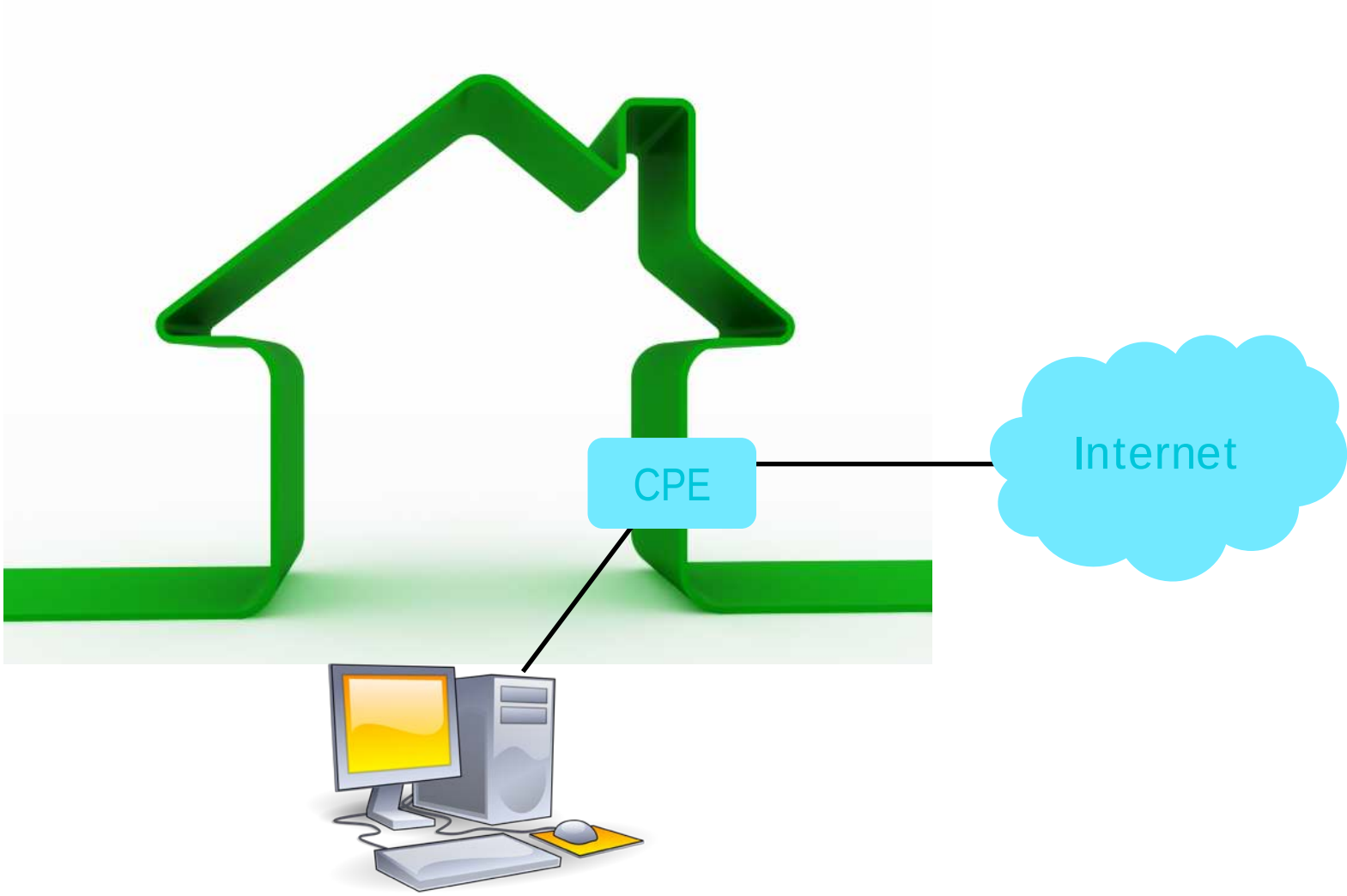
CDNs tomorrow… Virtual CDNs at the Edge



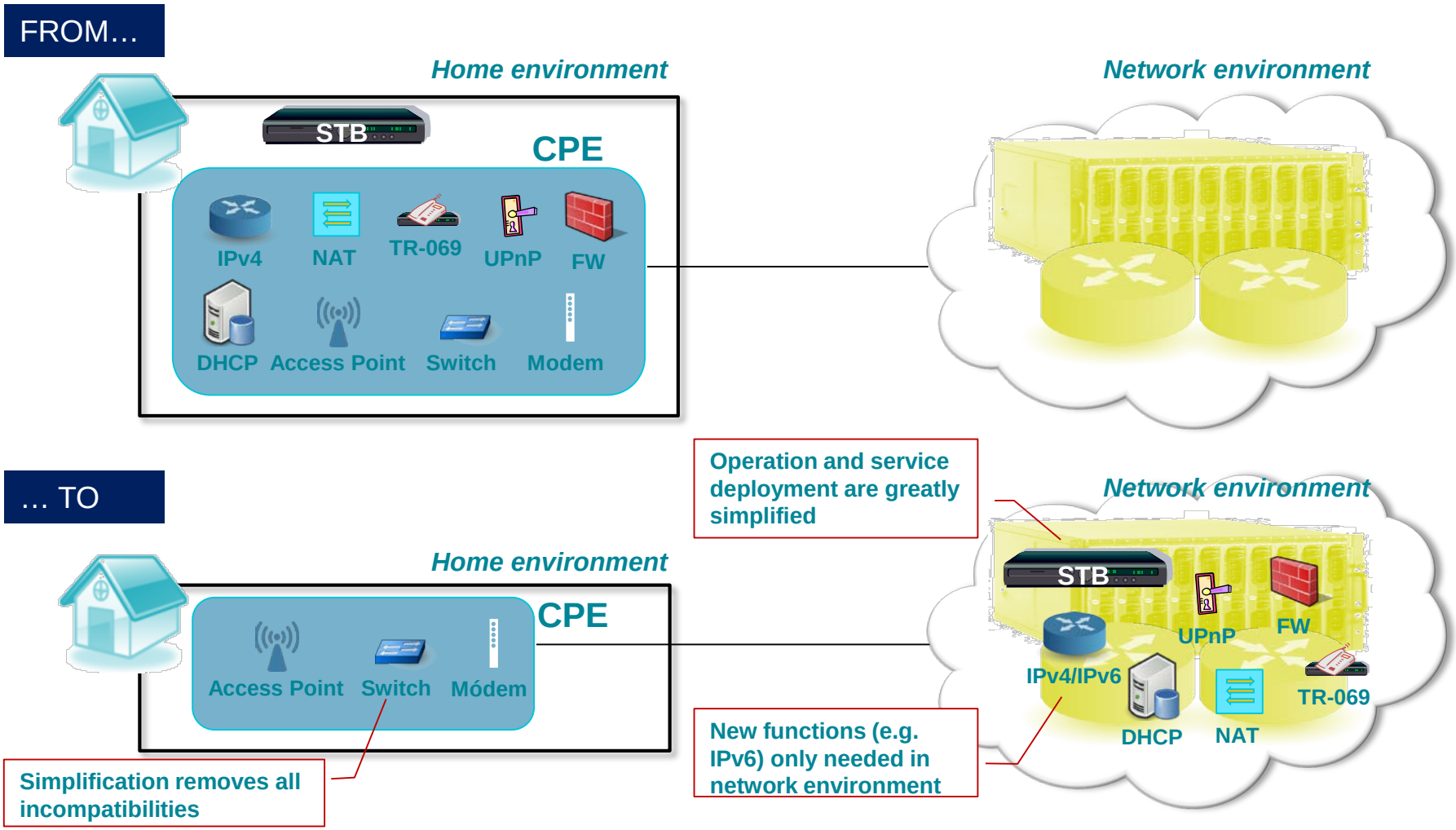
The connected home of the past



The connected home of today

http://www.ericsson.com/res/docs/2014/virtual-cpe-and-software-defined-networking.pdf

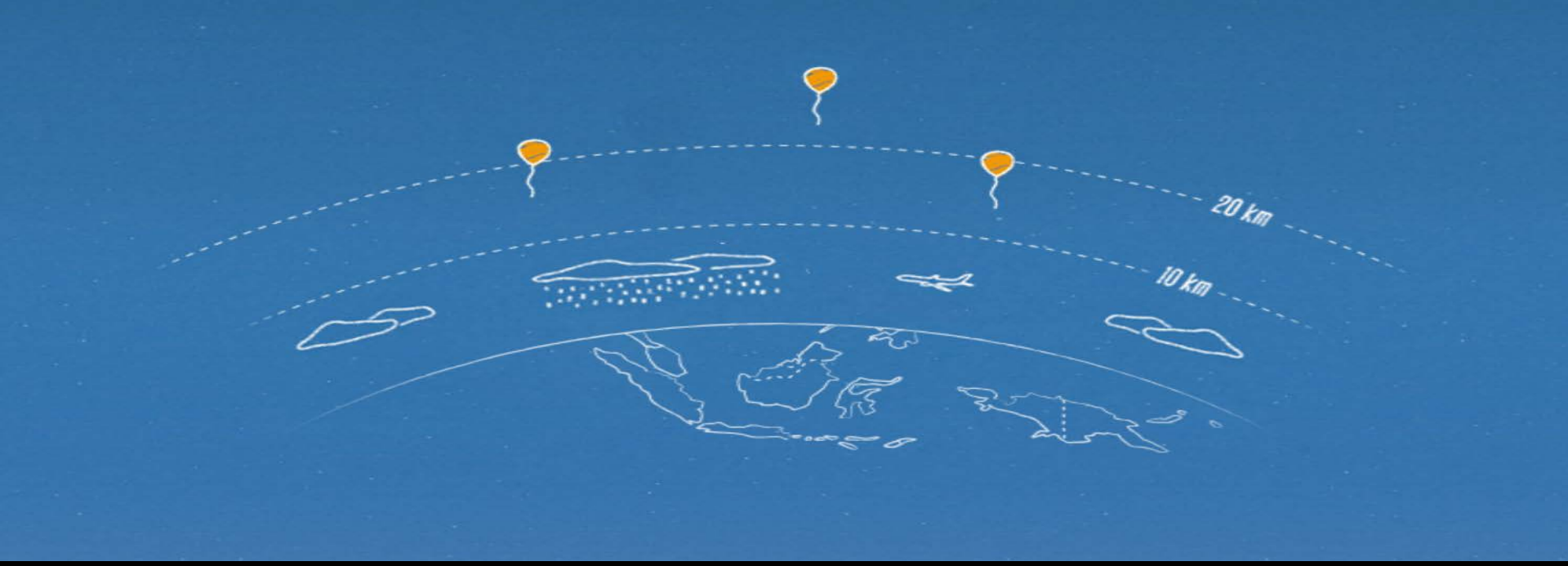
Innovation in services: The vCPE Principle



Credit: Antonio Elizondo, Diego Lopez, Telefonica GCTO

Project Loon had been testing in Peru with telecom company Telefonica for months. So when flooding and mudslides ravaged Peru this spring, the infrastructure was already in place to provide emergency internet for those affected. The company announced its successful Peru efforts on Wednesday.

CNN tech



USING A HIGH ALTITUDE PLATFORM (HAP) AS A RELAY SYSTEM INCREASES BANDWIDTH

Disruptive Edge Computing Where is the “killer app”?

Edge computing is still in its infancy and a framework to facilitate its adoption is not yet available.

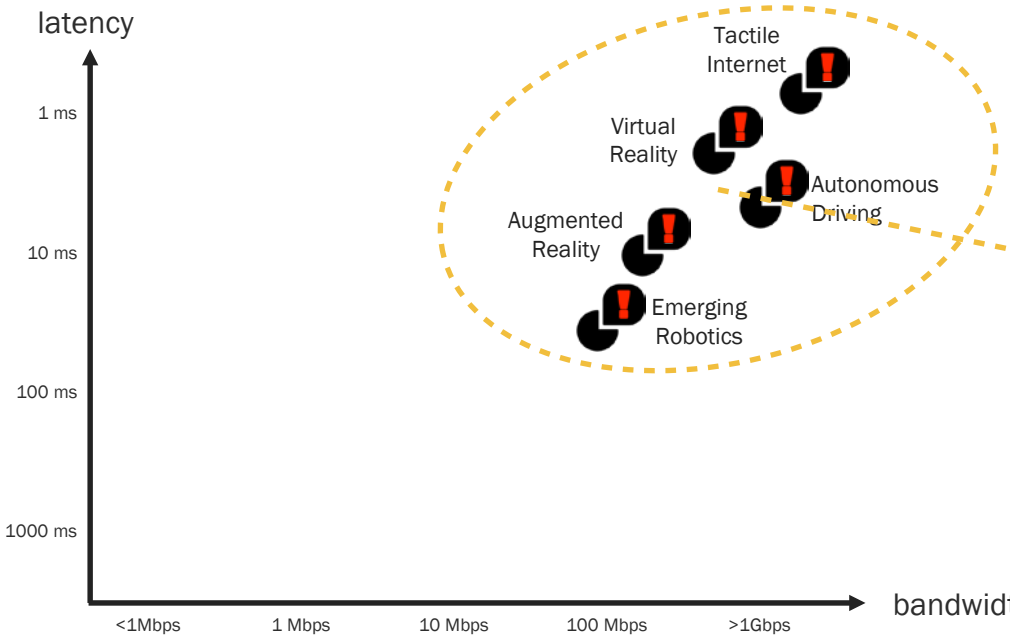
Some use cases are only emerging (e.g. VR/AR will be a niche for some time and industrial IoT is a very narrow vertical).

How to create the market demand? Nobody will develop apps that require <10ms latency unless there is enough demand for low latency apps. Biggest problem will be to break the cycle.

Biggest driver of the cloud is economic efficiency. **What is the economic incentive for edge computing?**

The killer app will come from the sweet-spot between bandwidth & latency.

THE ADVENT OF EDGE COMPUTING



Most suitable-for-the-edge use cases are heavy on **video and computer vision**

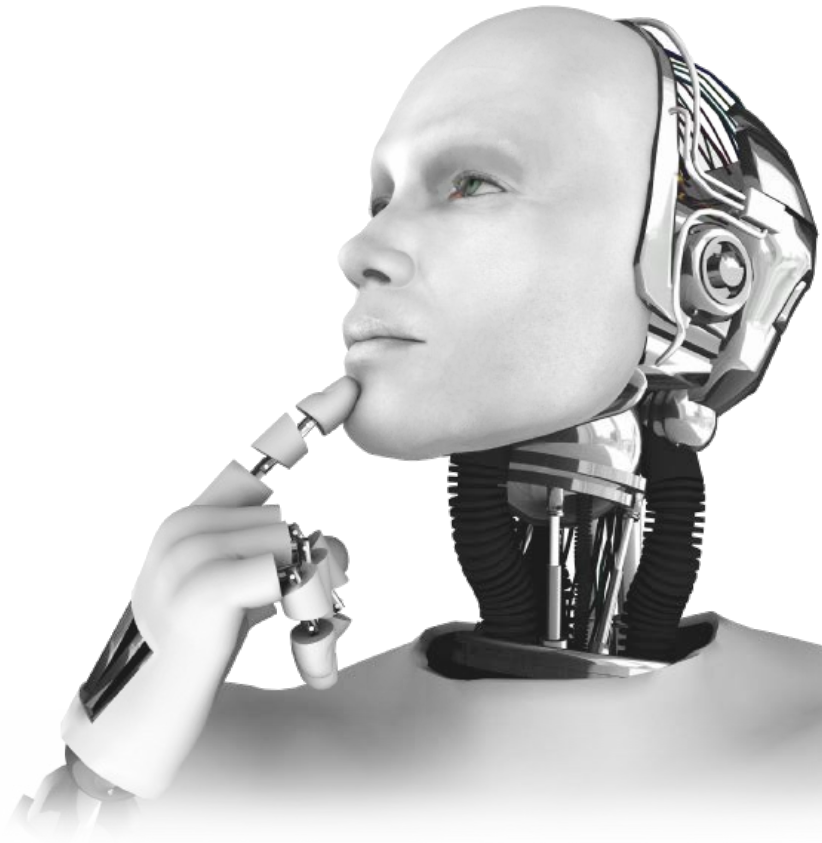
First, it’s the AI, stupid.

AI-powered applications will catalyze the adoption of edge computing. It is all set to become the most preferred architecture for running data-driven, intelligent applications.

IDC estimates that today, only 1% of application across all industries have some type of cognitive technology.
In two years that number will exceed 50%.

Edge computing prioritizes agility over power. Endpoints will never be as powerful as the cloud can be. On the other hand, they gain agility from the speed of the information loop that occurs in the edge, processing just the information that is needed.

The cloud will then become a place where learning happens.



AI Fields and Applications

ENABLING EDGE COMPUTING

SENSE

Perception

Use input from sensors to deduce aspects of the world. Computer vision. Speech, facial and object recognition.

Social Intelligence

Recognise, interpret, process, and simulate human affects, emotions and social skills.

INFER

Knowledge Representation

Representation of "what exists", qualification and commonsense.

Natural Language Processing

Read and understand the languages that we speak. Machine translation.

Creativity

Systems that identify/assess creativity or generate outputs that can be considered creative.

ACT

Reasoning and problem solving

Make logical deductions dealing with uncertain or incomplete information.

Planning

Set goals and achieve them. Also in cooperation (swarm intelligence).

Motion and Manipulation

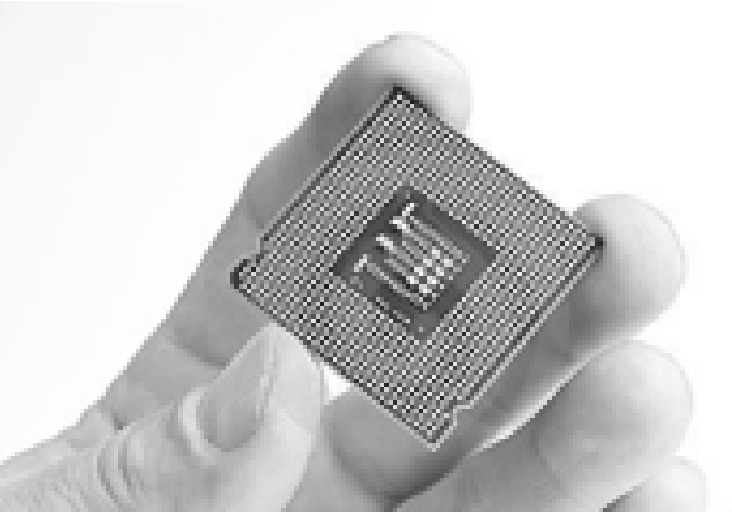
Robots to be able to handle such tasks as object manipulation and navigation.

LEARN

Algorithms that improve automatically through experience.

Secondly, specialised hardware will be needed

To enable edge computing, besides AI processors and algorithms, there's the increasingly important task of creating **engineering systems to maximise performance.**

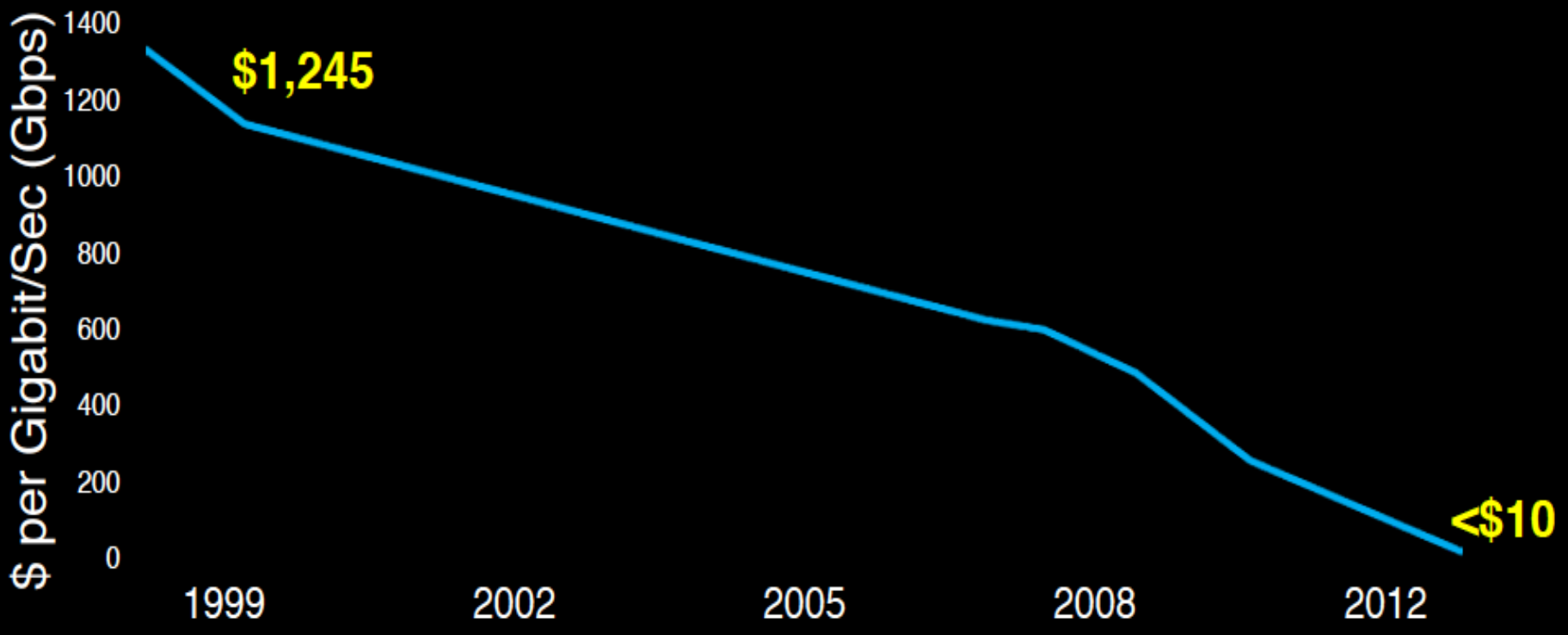


New and specialised chips and systems are needed to take AI to the next level. **Boutique chips will be developed to deliver better performance** and massively reduce training requirements and improve costs.

The objective is to build computational platforms that deliver the performance and energy efficiency needed **to build AI with a maximum level of accuracy.**

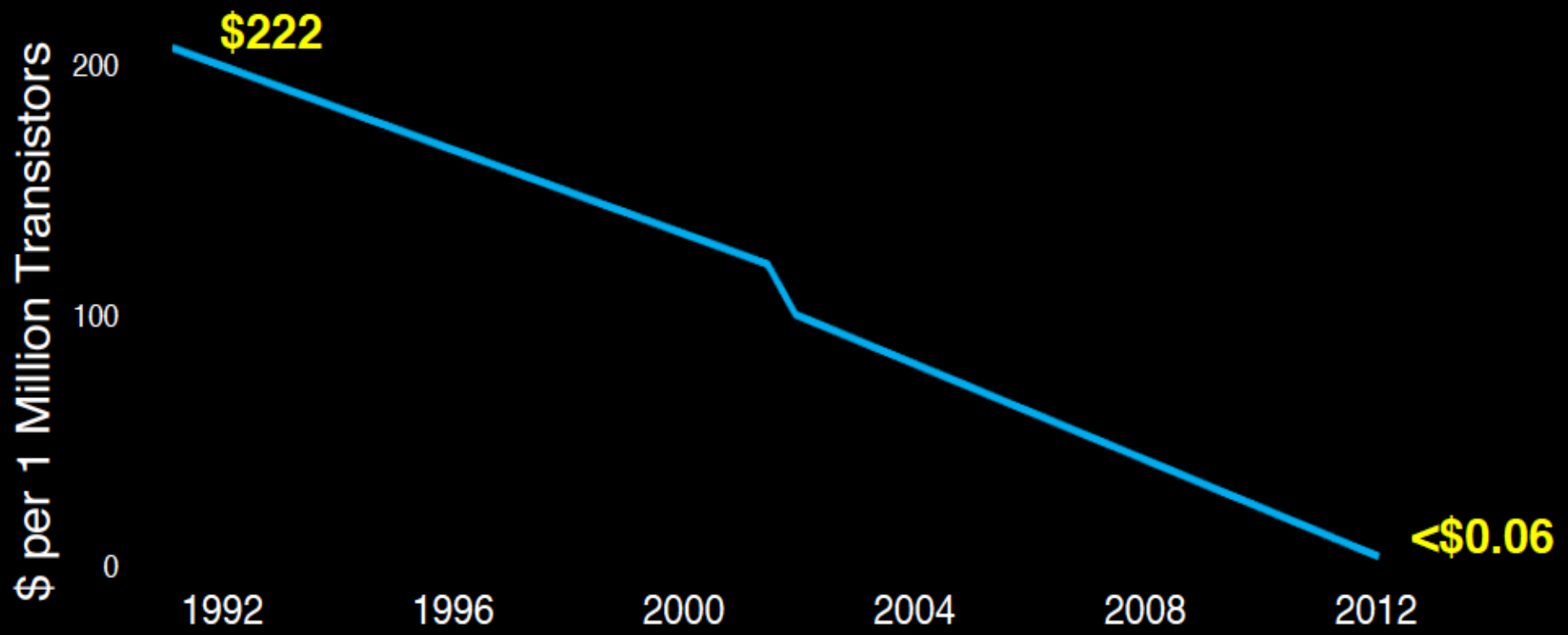
3 Data Control at the Edge

Bandwidth Cost-Performance (1999-2012)



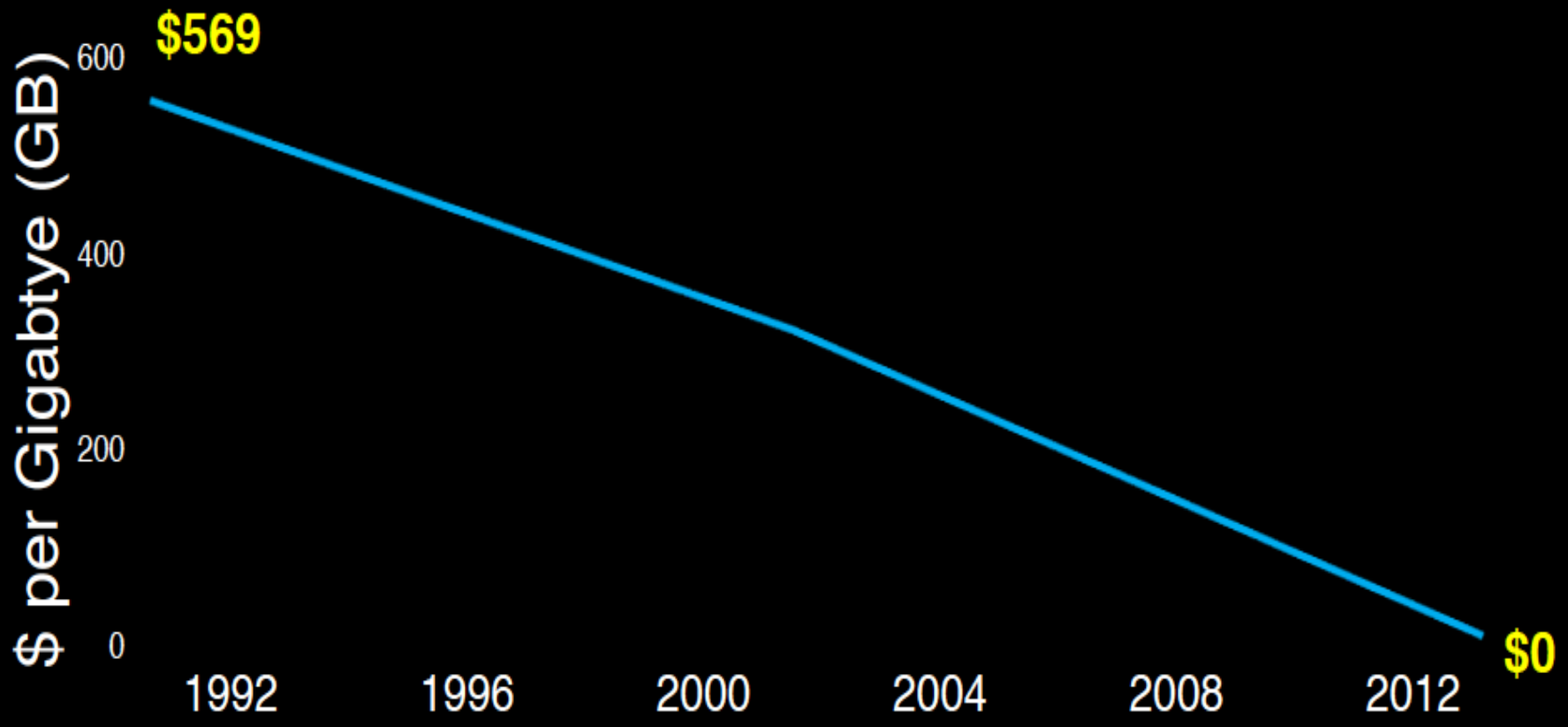
Source: Deloitte University Press

Computing Cost-Performance (1992-2012)



Source: Deloitte University Press

Storage Cost-Performance (1992-2015)



Source: Deloitte University Press

$0

computing abundance means

data driven world

data is your differentiator

competition

currency

"Biggest risk for the Web: Losing control of Data",

Sir Tim Berners-Lee 2017

Personal Data at the Edge is far more valuable than aggregated data. The more private/intimate and the closer to the context of the user, the more valuable it becomes.

Increase in value of contact as it becomes attached to an identity	→ x2	→ x6	→ x65	→ x320	→ x545
	Anonymous profile with 1 identifier	**Anonymous profile** with 34 identifiers	**Value per "friend" per Facebook profile**	**Location Data per contact in DB**	**Demographics data per contact**	**Buying Behavior & Preferences**
	$0.10	$0.18	$0.62	$6.50	$32.15	$54.50

Papadopoulos et al., “If you are not paying for it, you are the product”, IMC 2017

Source: Atos Group

Revenue comparisons

- World GDP = $70,000 B
- Telco Revenue (>50% Wireless) = $2,000B
- Personal Data (Ads) Revenue = $500B
- Video/TV Revenue = $182B
- Transit Revenue (Level 3) = $6 B
- Akamai 2011 Revenue = $1.2 B

TRANSPARENCY

... consumers are concerned

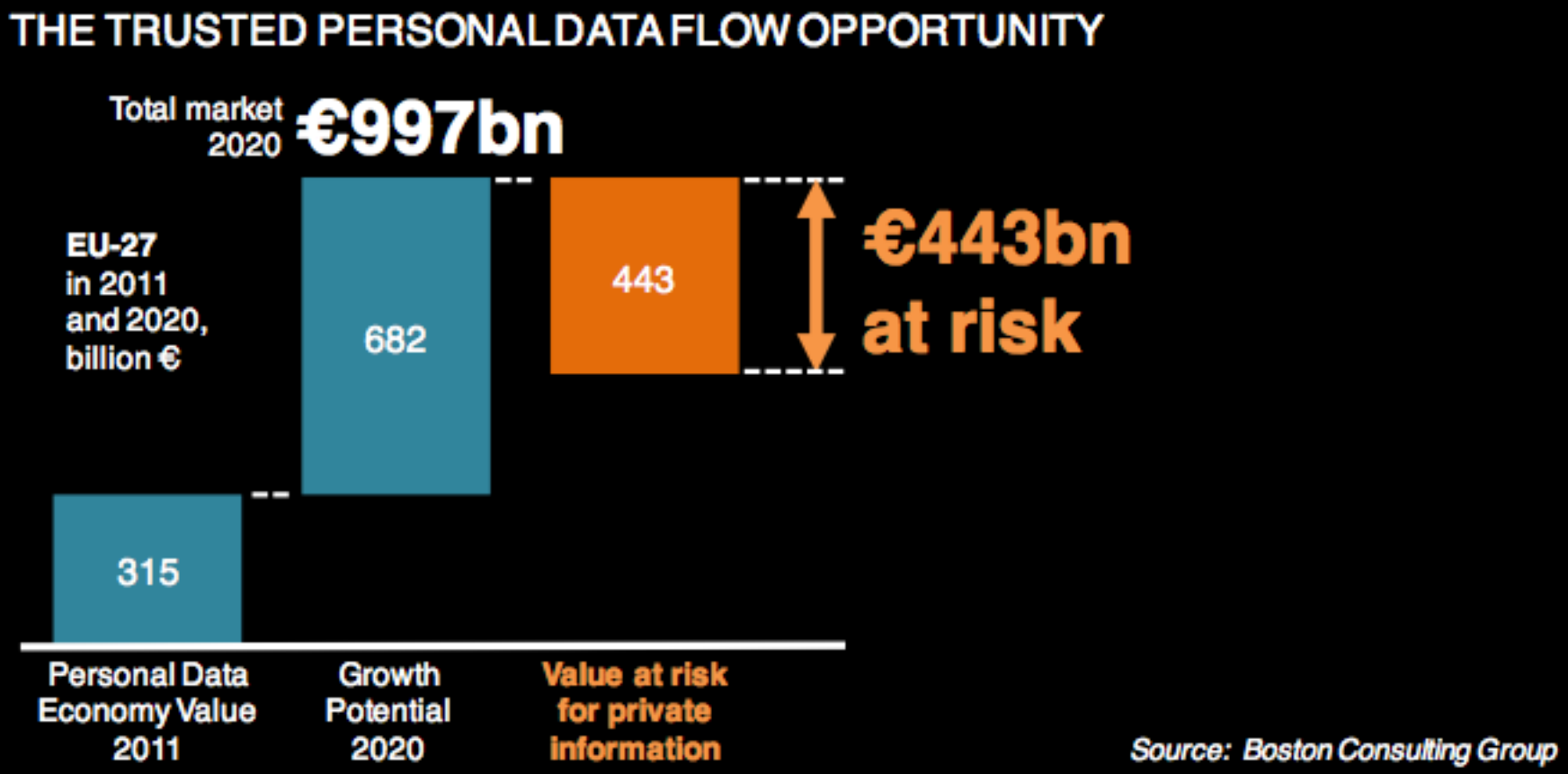
Most important concerns:

- What are the consequences of sharing my data
- What do they do with my data
- Who is tracking my data
- Who has my data
- How can I control where my data goes
- What kind of data are they tracking
- What can I do to delete my data

Data obtained using a card sorting prioritization exercise

Consumer types:

Two thirds of the potential personal data value is at risk if stakeholders fail to establish a trusted personal data ecosystem



Source: Boston Consulting Group

people don’t care about privacy

smoke

societies evolve

Edge Functionality Evolution

Privacy/Data Control

(e.g. IID protection, Data Control, Anti Tracking, Transparency, Data Banks)

Analytics/Algorithms

(e.g. Vision, AI/ML as a service, Big Data, Cognitive Decision, Situational awareness)

Application Improvements

(e.g. Compression, Caching, Edge insertion, Cyber Security)

Protocol Optimizations

(e.g. Delay-jitter algorithm, ACK regulator, Pacing)

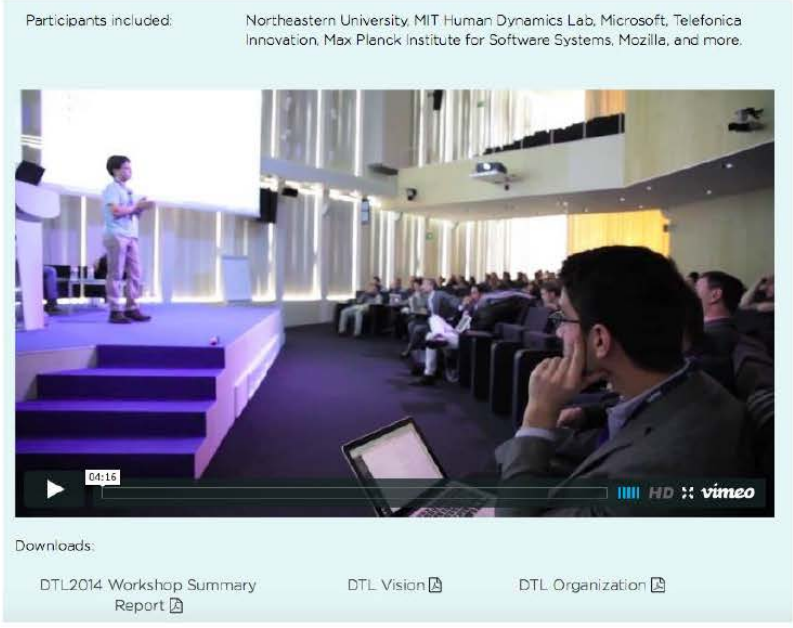
Launch of Data Transparency Lab

ODI · Telefónica · MIT Connection Science · mozilla

DATA TRANSPARENCY LAB

A community of technologists, researchers, policymakers and industry representatives working to advance online personal data transparency through scientific research and design.

Kick-off Workshop : Nov'14, Bcn



Naylor et al, “McTLS: Enabling secure in-network Funcionatlity in TLS”, Sigcomm 2015

PARENTAL FILTER
MALWARE
VIRUS
AD MANAGEMENT

PRIVACY DATA PROTECT
BLOCK OF TRACKING
IDENTITY TRANSLATION-PROTECTION

EDGE TREND: In-Network Privacy Control Functionality

Personal Data: Give Data and Value Back

- Individuals leave data traces (location, calls, web traces, shopping, etc)
- Such info is useful for Credit Ratings, Retail Industry, Govs, Online Advertising, Predictions and Analytics (Sexual Orientation, Political Views)
- Individuals have multiple virtual Data Souls and Personalities
- Individuals with access and control of that data could use it to their benefit
- We still live in a “data desert”: we don´t know much about ourselves or the world (where do people like me go, where is it safe, where can I find a job)
- Give value back to our customers

- “For sale: Your Data: By you”, Hotnets 2011

Erramii et al, “For sale: Your Data: By You”, Hotnets 2011

Personal Data Banks

Our data is fragmented across the web

Bringing it together unleashes its true potential

Exchanging it creates mutual benefits for all

future

INDIVIDUAL AS THE NEW PLATFORM

- “My Data Soul”, P. Rodriguez TEDx Talk
- www.rodriguezrodriguez.com

4 Main Takeaways

The edge in a nutshell

- It’s about moving **computation and storage closer to where data is created** and acted upon
  - It’s so far being transformational
  - There will be many edges
- The disruptive opportunities will come from use cases that require high bandwidth and low latency; **mainly video and computer vision.**
- **The Edge will enable AI in Real Time as a service**
- **Specialised Hardware will be the catalyser**
- It will require really huge investments and cross industry strategic partnerships with sticky relationships. **It will not happen by chance.**
- Privacy, Security and Data Value and control will drive a large percentage of Edge use cases

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