**Korean-German Workshop
Future Internet Research**

**Media as a Service – Personalized & immersive media
will shape the Internet's future architecture**

Peter Domschitz
Bell Labs
8 March 2011

Alcatel·Lucent

Agenda

Everything is Video / Immersive Communication

Bandwidth Demands Exceeding the Limits

Offloading Networks by Intelligent Content Delivery

Everything goes Cloud

Challenge: Personalized Services

Game Changer: Move Applications not Data

Building a Networked Cloud for Media Services

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Using video to communicate isn't exactly a new idea...

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The technical barriers are falling…

The devices were too expensive…

…but HD webcams now cost $50
and 37" HDTVs cost $500…

It was too complicated to set up…

…but Skype has 500M users and
videochat is now a feature in Gmail

**The network couldn't support
high-bandwidth media…**
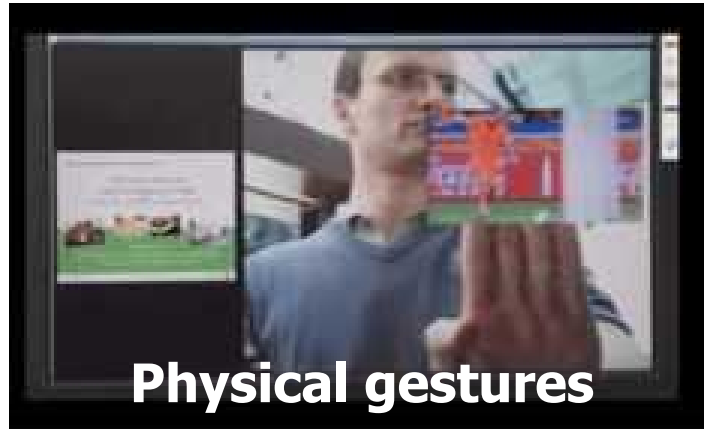
…but Hulu and Netflix
serve television to millions

…but the experience is still "videophone"

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The technology is capable of so much more

What is "different"? Things like…

Physical gestures

Composed scenes

…delivered without dedicated devices

How?
Powerful video algorithms running
in the network

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Immersive Communication

Mixed Reality
- Virtual director,
- Head & pose tracking, spatial audio...

Natural Human Interaction
- Gesture control
- Augmented Reality

Anywhere, Any Device
- PC, mobile,
- Tablet, TV

Cloud Architecture
- Cloud based video processing,
- Encoding, GPU, rendering

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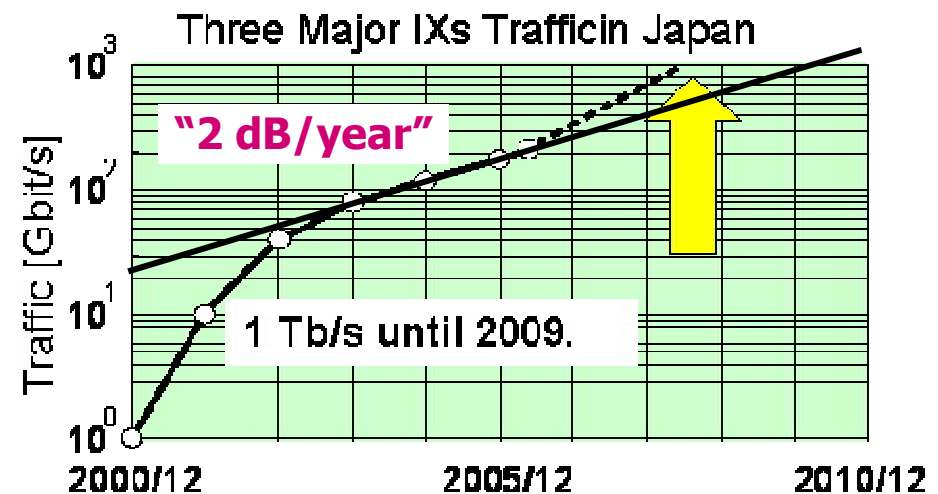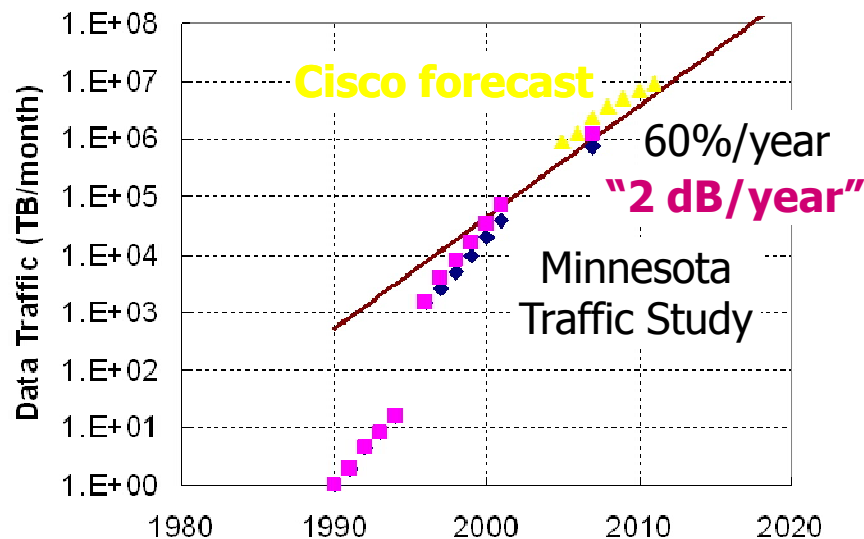
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Implications on the Internet Infrastructure
The need for digital transport is growing exponentially

Information is of little use if you have to keep it to yourself

→ Humans have a desire to interact (cell phones, YouTube, …)

→ Requires huge *transport capacities* (especially for real time app's)

BBC iPlayer

YouTube

Telepresence

Cisco forecast

60%/year
"2 dB/year"

Minnesota
Traffic Study

Data Traffic (TB/month)
1.E+08
1.E+07
1.E+06
1.E+05
1.E+04
1.E+03
1.E+02
1.E+01
1.E+00
1980 1990 2000 2010 2020

Three Major IXs Trafficin Japan

Traffic [Gbit/s]
10^3
10^2
10^1
10^0

"2 dB/year"

1 Tb/s until 2009.

2000/12   2005/12   2010/12

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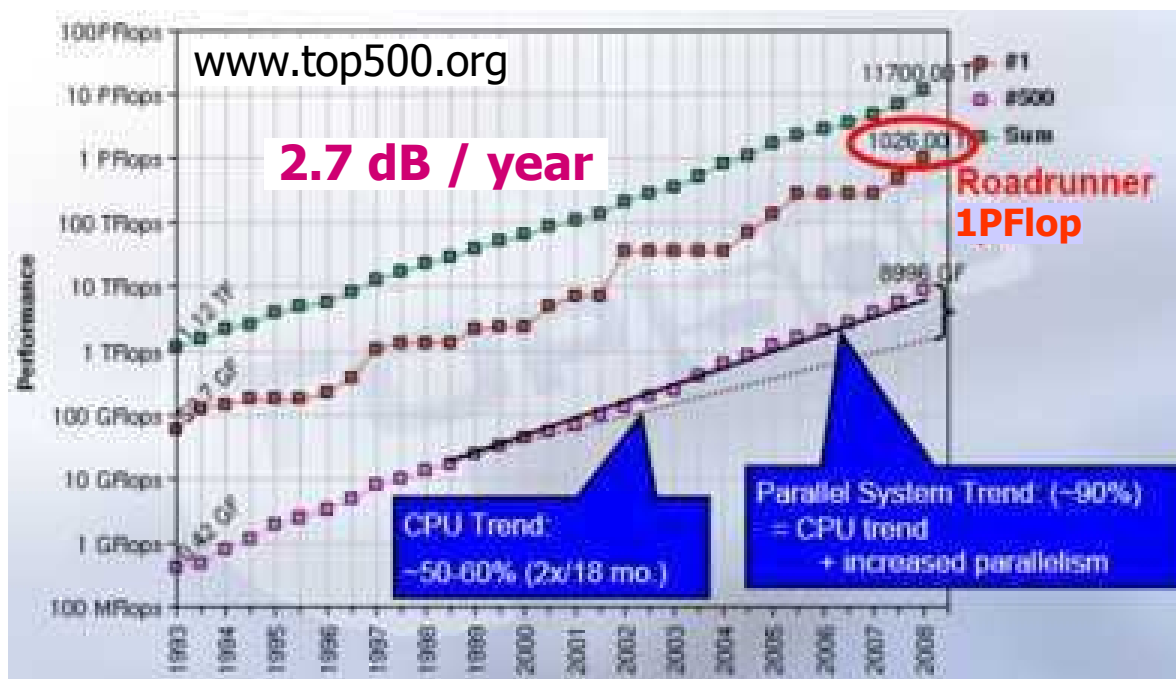# Implications on the Internet Infrastructure
The need for digital transport is growing exponentially

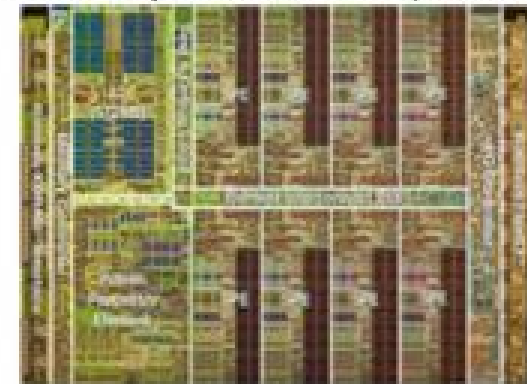**Computers also want to talk (Amdahl's rule of thumb):**

→ 1 Floating point operation (Flop) triggers ~1 Byte/s of transport
(even more so when using multi-core processor architectures!)

Coupled with exponential growth in computing power

→ Exponential growth in computer-generated transport capacity

www.top500.org

2.7 dB / year

Roadrunner
1PFlop

CPU Trend:
~50-60% (2x/18 mo.)

Parallel System Trend: (~90%)
= CPU trend
+ increased parallelism

IBM Cell Processor
9 processors, ~200GFLOPs
On- and Off-chip BW~100GB/sec (0.5B/FLOP)

Courtesy of Petar Pepeljugoski, IBM

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Implications on the Internet Infrastructure
Issue: The scaling of WDM is nearing its End
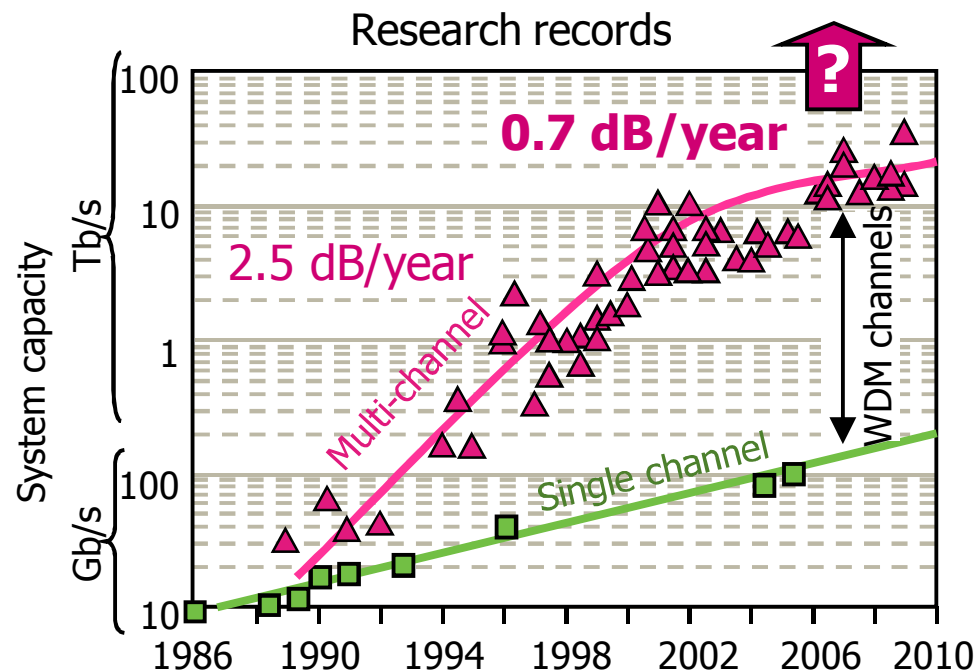
Over the last 20 years, WDM has enabled enormous transport capacity growth

The optical amplifier (EDFA) was _the_ enabling technology for its commercial success

➔ **The scaling of WDM is no longer guaranteed**

Agenda

Everything is Video / Immersive Communication

Bandwidth Demands Exceeding the Limits

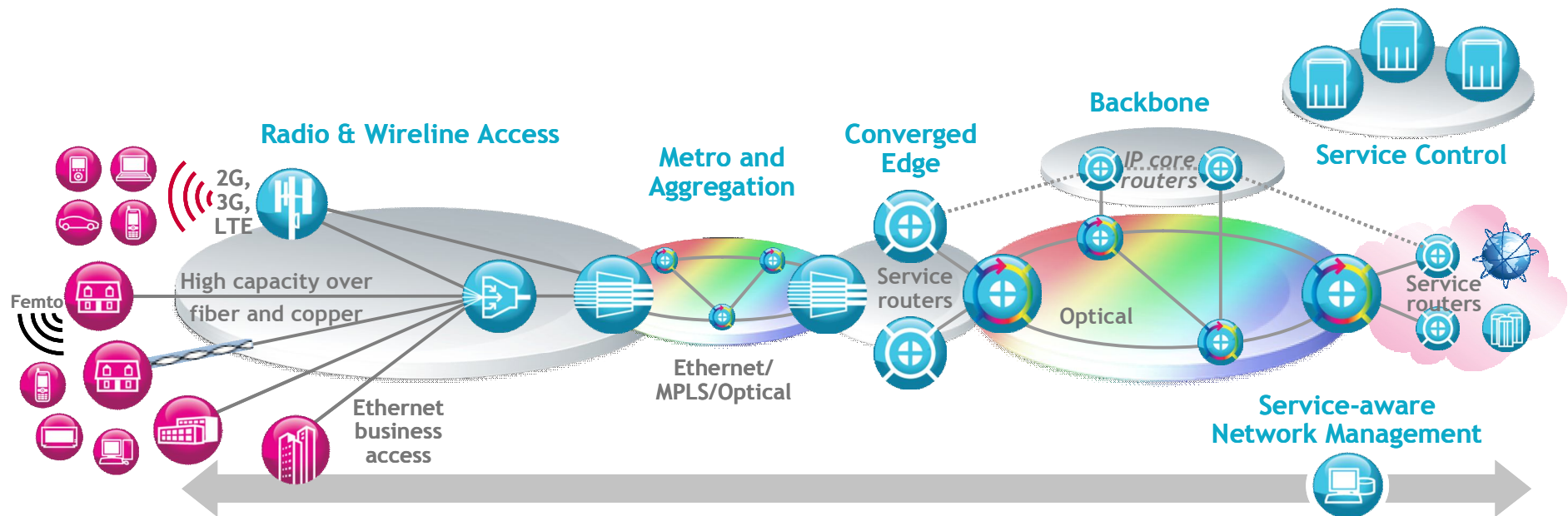**Offloading Networks by Intelligent Content Delivery**

Everything goes Cloud

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Making the Network more Efficient
High Leverage Network^{TM}

Radio & Wireline Access

2G, 3G, LTE

Femto

High capacity over fiber and copper

Ethernet business access

Metro and Aggregation

Ethernet/ MPLS/Optical

Converged Edge

Service routers

Backbone

IP core routers

Optical

Service Control

Service routers

Service-aware Network Management

Alcatel·Lucent
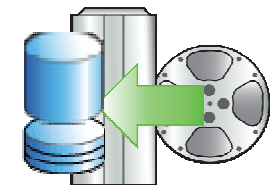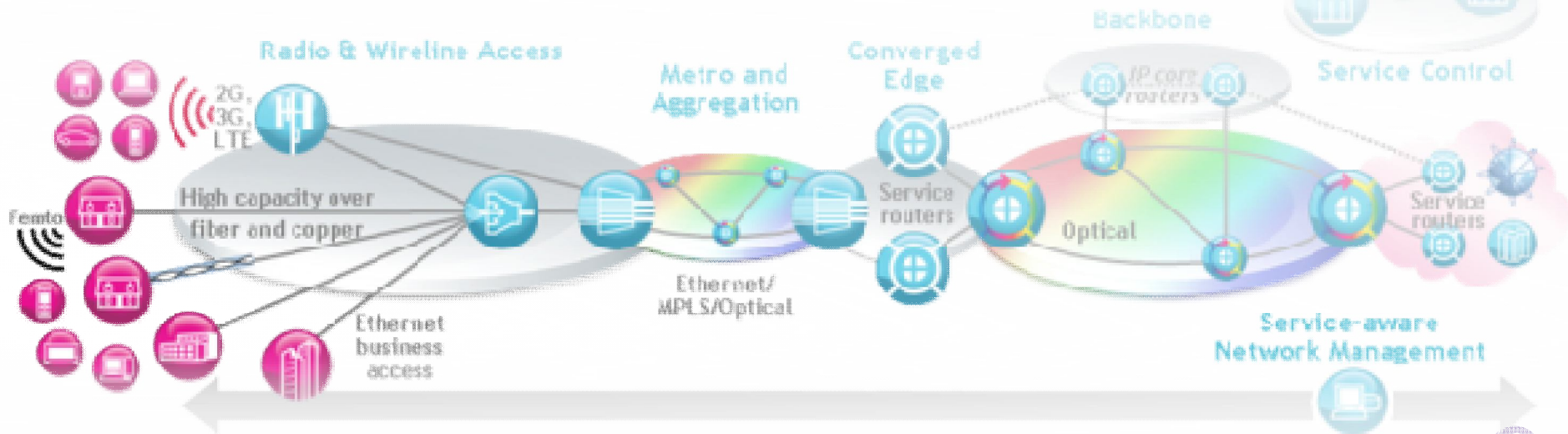
Making the Network more Efficient
Server-based Content Distribution

➔ This doesn't scale!

Individual content streams
(transporting the same content)

Content Server

Radio & Wireline Access

2G,
3G,
LTE

Femto

High capacity over
fiber and copper

Ethernet
business
access

Metro and
Aggregation

Ethernet/
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Service
routers

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IP core
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Optical

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routers

Service-aware
Network Management

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Making the Network more Efficient
Content Delivery Networks

CDN Elements
- Publishing Appliance
- DNS Content Routing
- Storage Appliance
- Delivery Appliance
- Utility Appliance
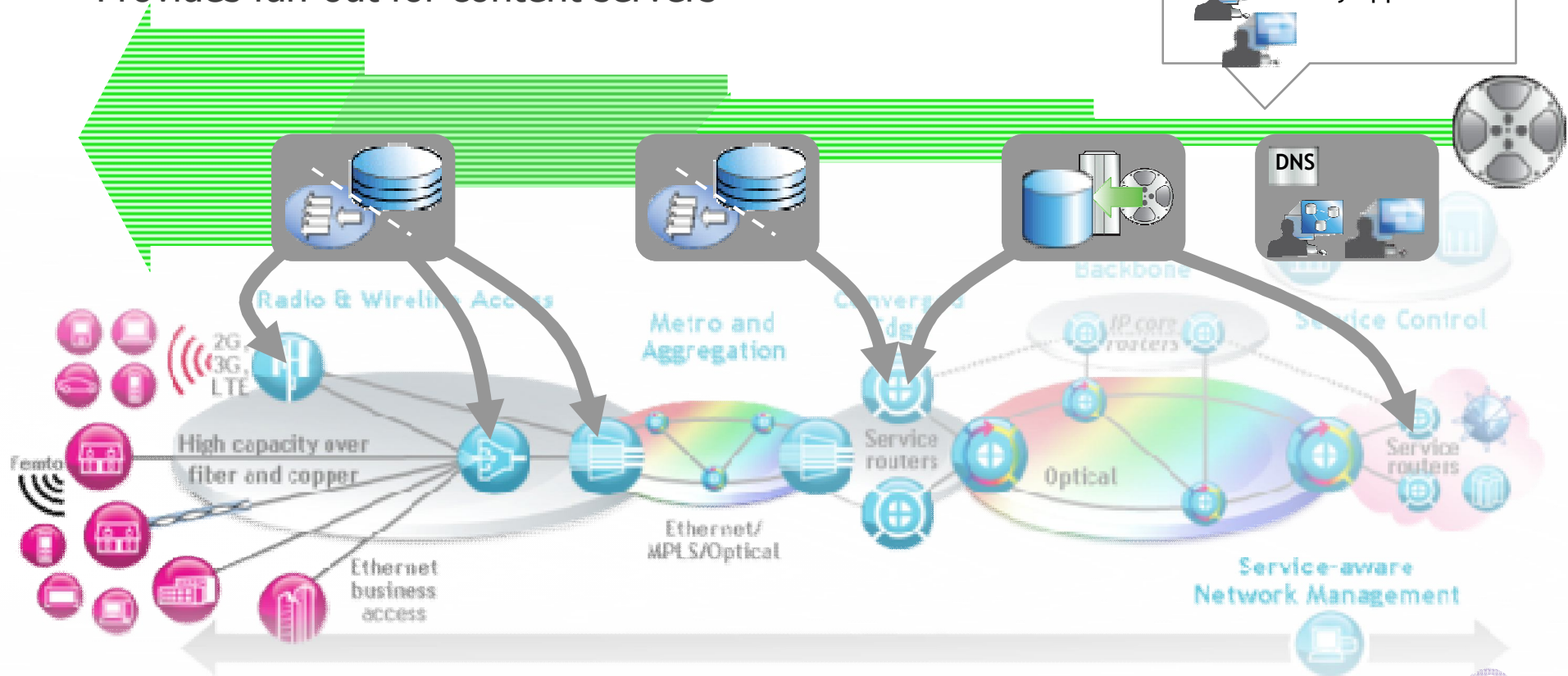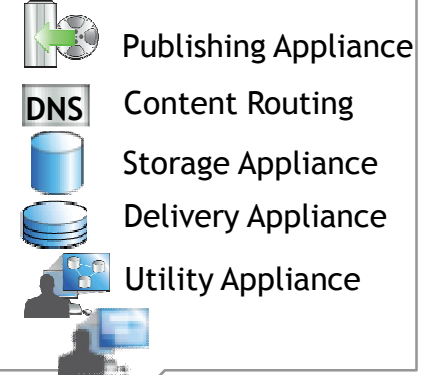
- **Efficient delivery of stored or live content**
  caching   multicasting

  - Offloads the networks and ISP peerings
  - Provides fan-out for content servers

Radio & Wireline Access

2G 3G LTE

Femto

High capacity over fiber and copper

Ethernet business access

Metro and Aggregation

Ethernet/MPLS/Optical

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Service routers

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IP core routers

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DNS

Service Control

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Service-aware Network Management

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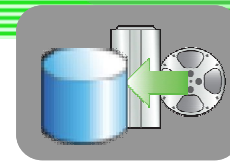
Making the Network more Efficient
Content Delivery Networks & Personalized Services

Fraction of consumer individual content is heavily increasing

DNS

- **CDN solved the issue to handle traffic increase up to now (thus compensating slowdown to 0,7 dB/year)…**

- **…but now we see the rise of personalized services going beyond today's "broadcasting" models…**

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Bandwidth Demands Exceeding the Limits

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Everything goes Cloud

Challenge: Personalized Services

Game Changer: Move Applications not Data

Building a Networked Cloud for Media Services

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Today's Cloud Solutions Solve Real Problems...

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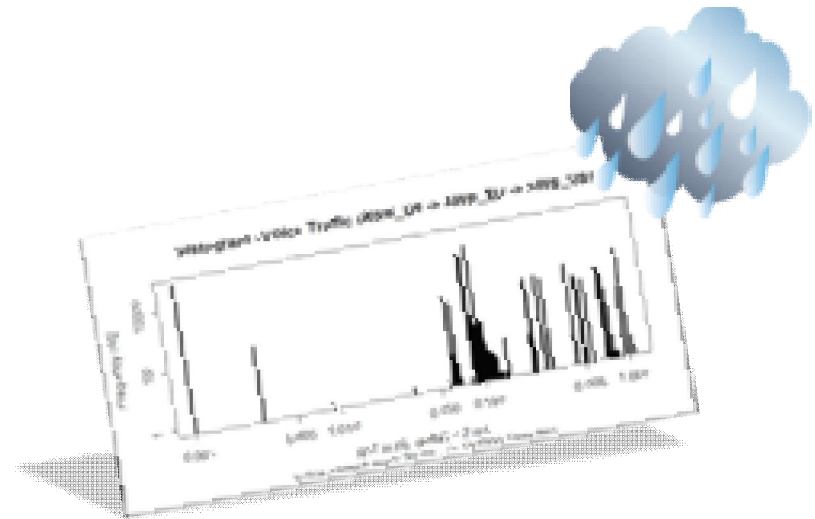
Today's Cloud Solutions Solve Real Problems...

But only certain kinds...

- Transaction oriented
- Stateless
- Relaxed time constraints

What about interactive services?

- Session oriented
- Stateful
- Rigid time constraints

Participants and media integrated into a common visual space

Gesture control of "carousel" of shared media

Our Focus:

TelCo-Applications, Immersive Services

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The Networked Cloud

Media-Rich Applications	Device-Rich Applications	Telco Applications

Processing	Network	Storage	Devices

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AT THE SPEED OF IDEAS

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Moving from Broadcast to Personalized Services
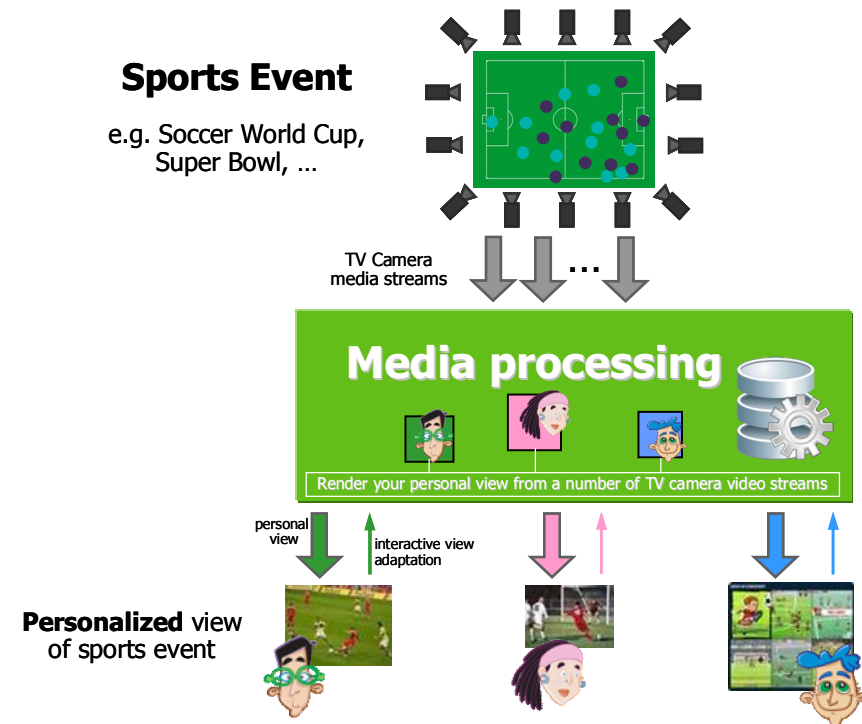## What we need is a Networked Cloud for Media Services

Future communication services will be media intense (i.e. video centric), most of the time requiring the processing of media content to individual users expectations...

Problem statement:

- **Networks will be 'challenged' to support increase in traffic...**
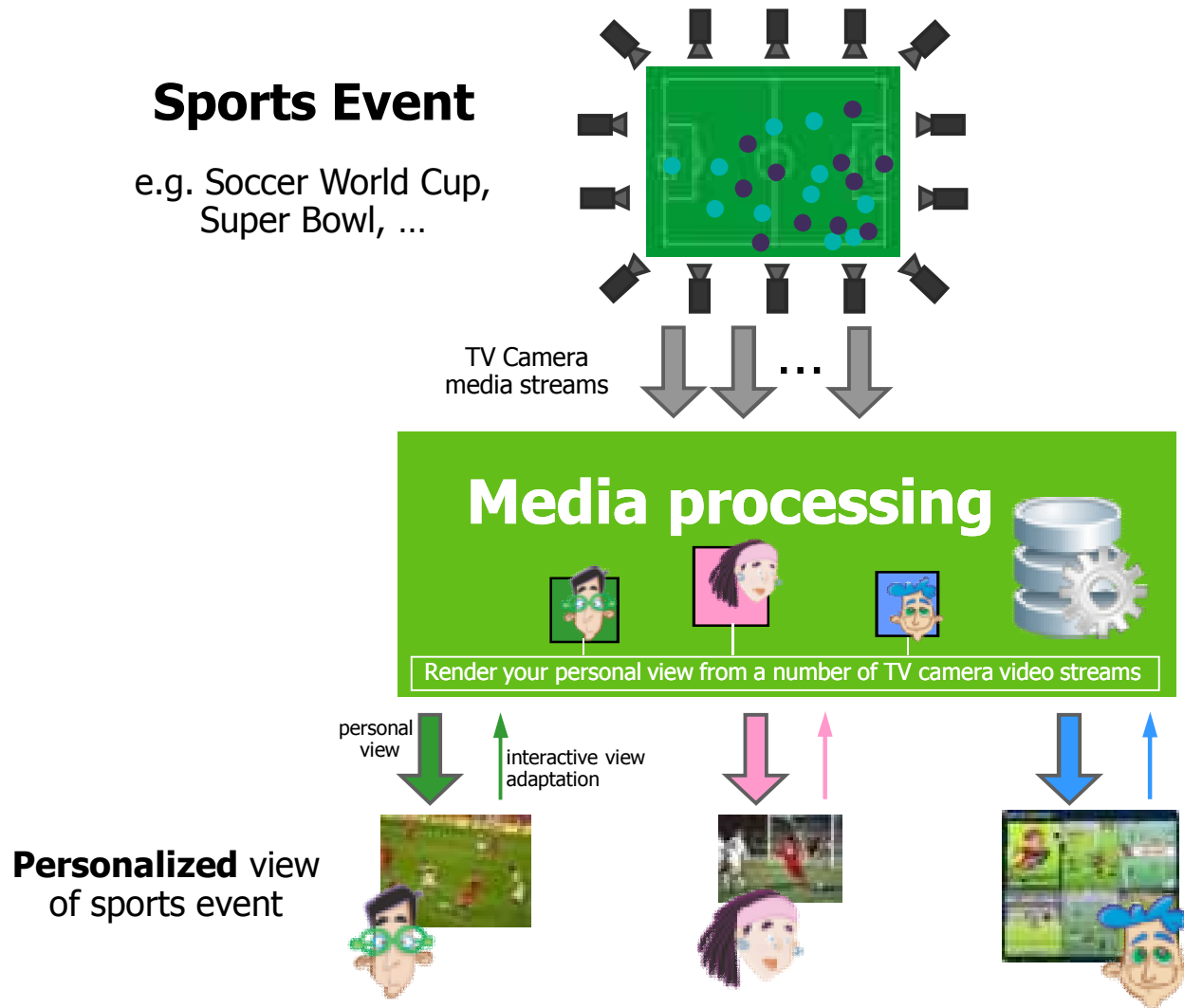- **Interactive services make high demands on required Quality of Experience (QoE)**

Example applications:

- **Personalized Viewpoint TV ·······>** or any other kind of personalized IPTV

- **Immersive** communication & collaboration **applications**

Sports Event

e.g. Soccer World Cup, Super Bowl, ...

TV Camera media streams   ...

Media processing

Render your personal view from a number of TV camera video streams

personal view   interactive view adaptation

Personalized view of sports event

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Personal Viewpoint TV Use Case
Schematic View

Sports Event

e.g. Soccer World Cup,
Super Bowl, …

TV Camera
media streams

Media processing

Render your personal view from a number of TV camera video streams

personal
view

interactive view
adaptation

Personalized view
of sports event

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Personal Viewpoint TV Use Case
How to implement that in a scalable way?

• "Cloud" approach...

Camera signals → amazon.com
Dublin
2018 Soccer world cup final
~ 200 million personalized media streams
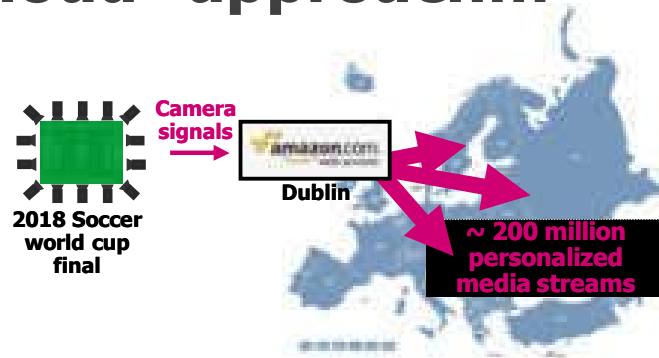
~200 million personalized media streams each ~20 MBit/s → 4.000.000 GBit/s

There is need for intelligent mechanisms which exploit distributed cloud resources to offload future transport networks...

Challenging environment to achieve required QoE

• Device centric approach...

(multitude of) Camera signals
2018 Soccer world cup final
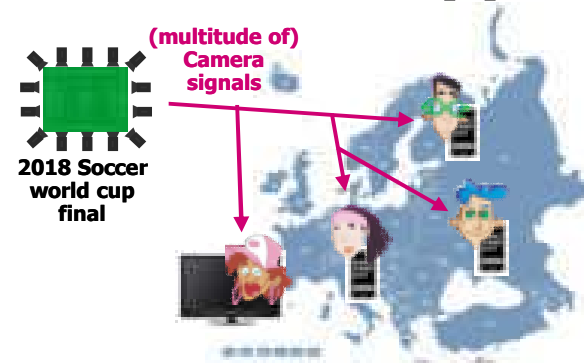
Limited bandwidth in the access...

Many devices will not support required processing performance...

Battery drain of mobile devices...

Issue of energy efficiency in the access...

→ **Need for service centric networking in distributed, heterogeneous cloud environments!**

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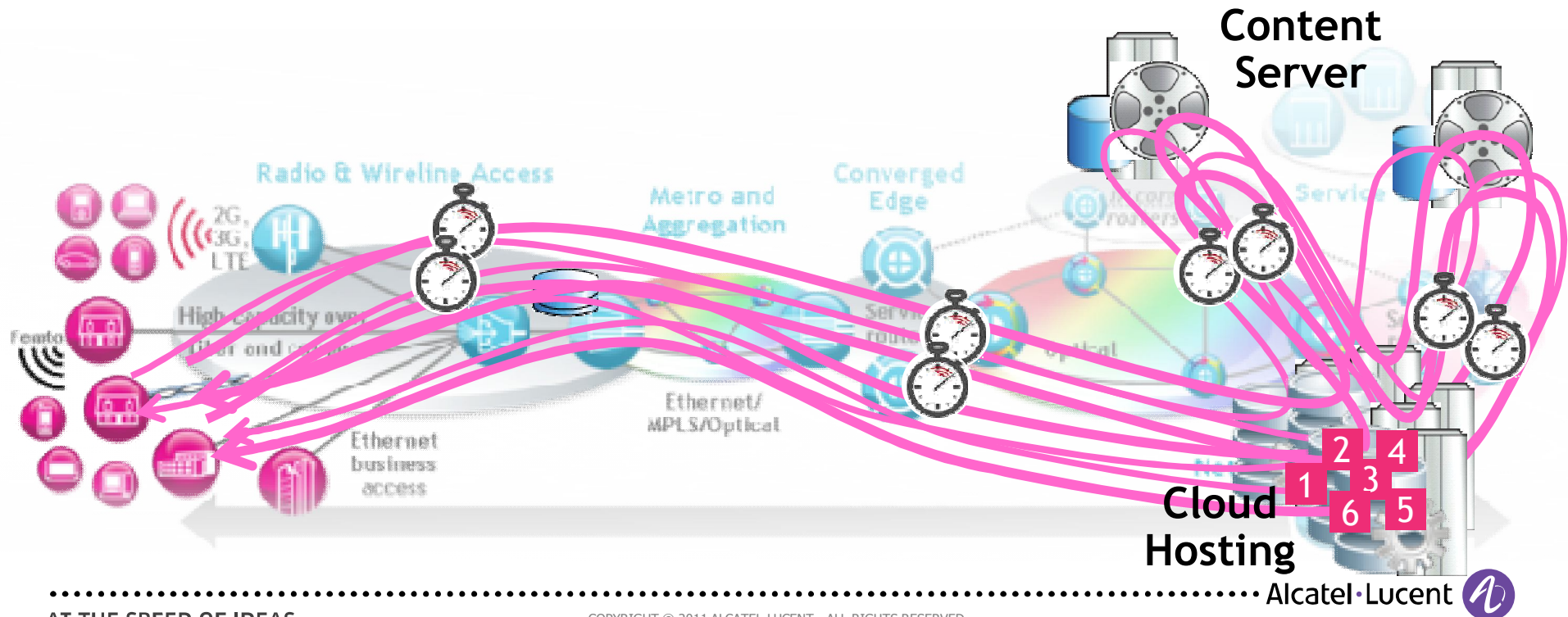**Game Changer: Move Applications not Data**

Building a Networked Cloud for Media Services

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Cloud vs. Internet Infrastructure
Challenge

A major issue with today's solutions is the movement of data between services... [1]

- **A person can use multiple times their access pipe's bandwidth in the core**

- **Latencies are too high for interactive, user-controlled services**

Content Server

Cloud Hosting

Radio & Wireline Access

Metro and Aggregation

Converged Edge

2G, 3G, LTE

Femto

High-capacity over fiber and copper

Ethernet business access

Ethernet/MPLS/Optical

AT THE SPEED OF IDEAS

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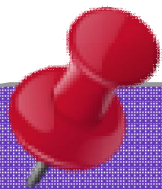
Cloud vs. Internet Infrastructure
Approach

Future media architecture must allow services to move to the data / user / content [1]

- Needs to evolve current architectures with service orchestration capabilities

- Needs to be easy to build to, allow mash-ups without complexity

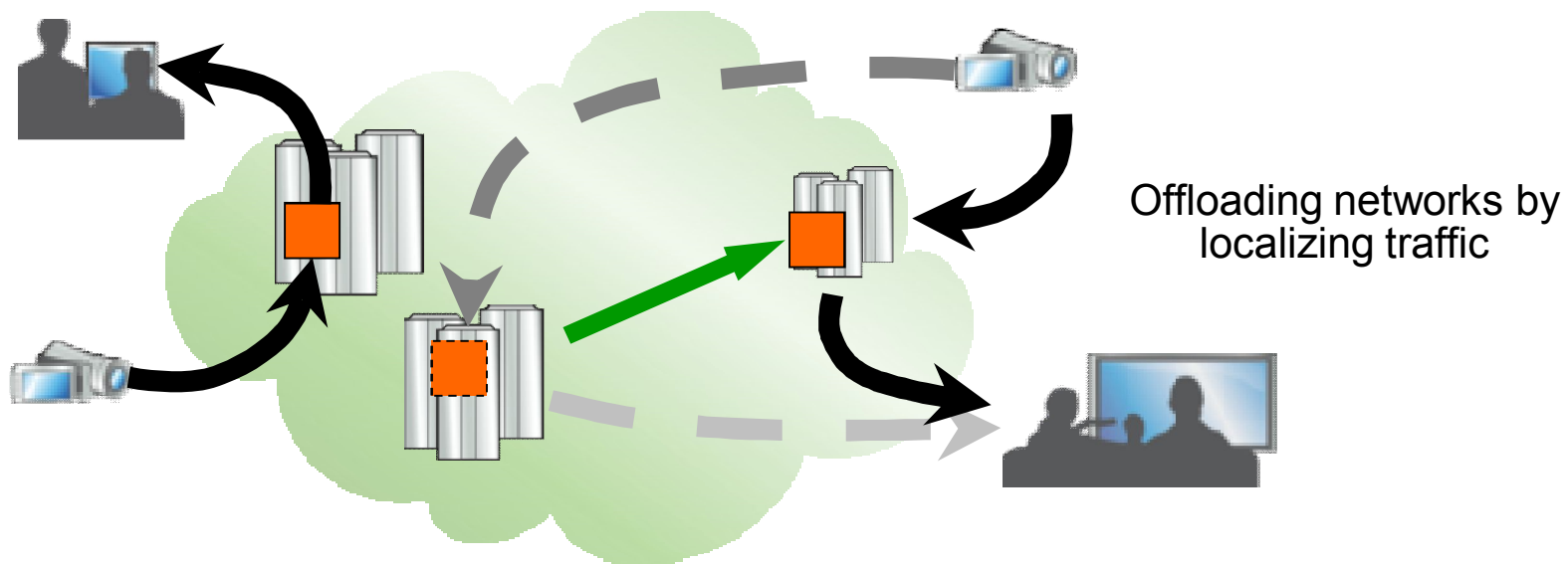**...blending transport, storage and processing**

Content Server

Distributed Cloud Resources
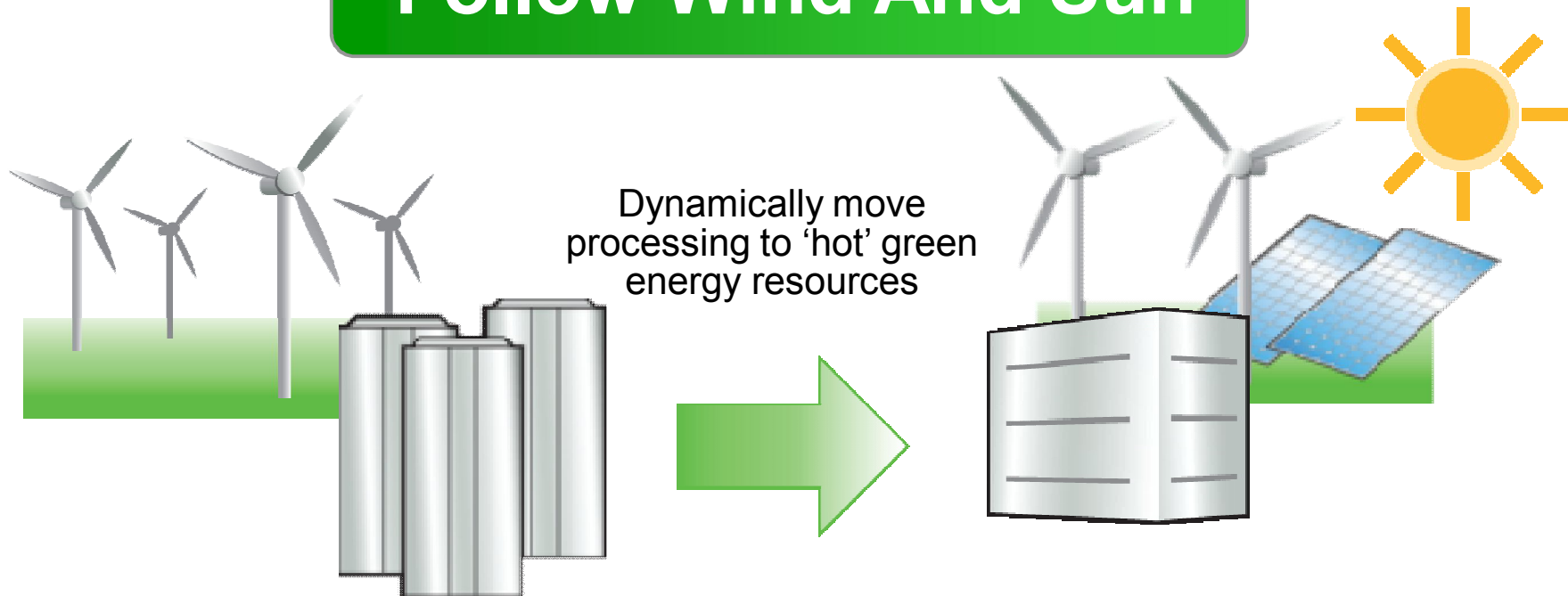
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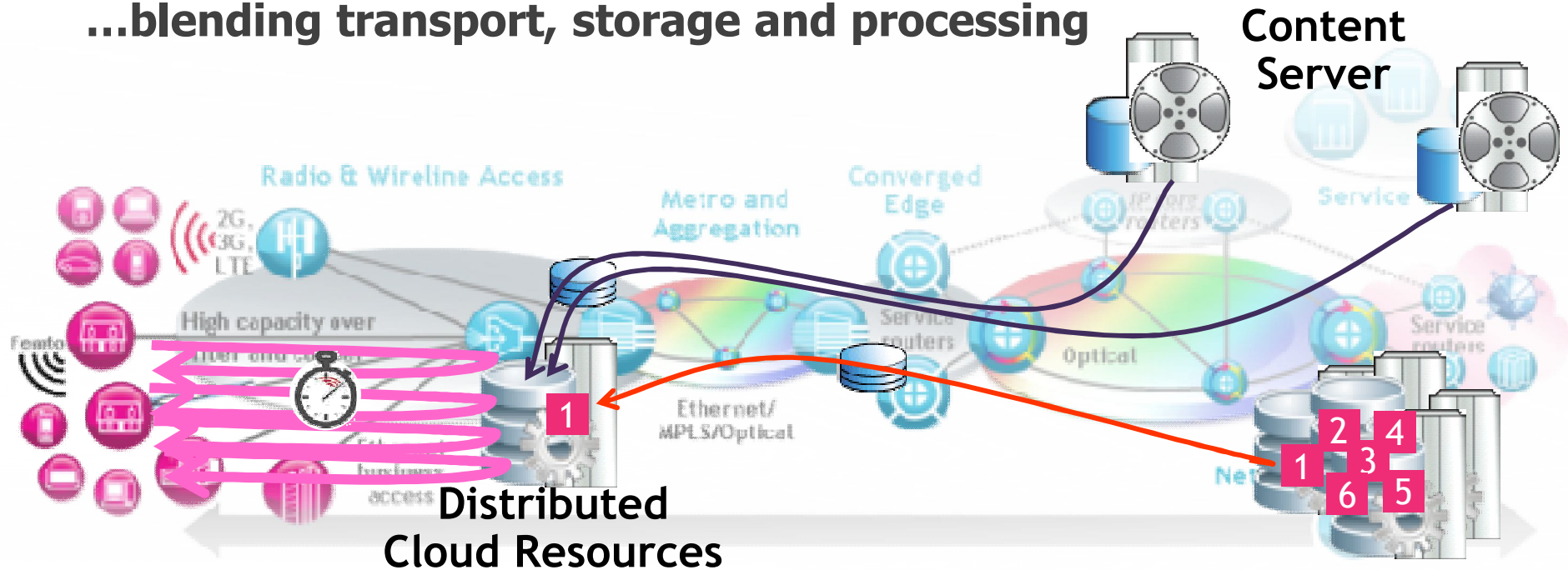
Change of Paradigm

Move Apps not Data

Offloading networks by localizing traffic

Change of Paradigm
Greening the Internet

Optical Mesh /w Micro Data Centers

Follow Wind And Sun

Dynamically move processing to 'hot' green energy resources

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Networked Cloud for Media Services
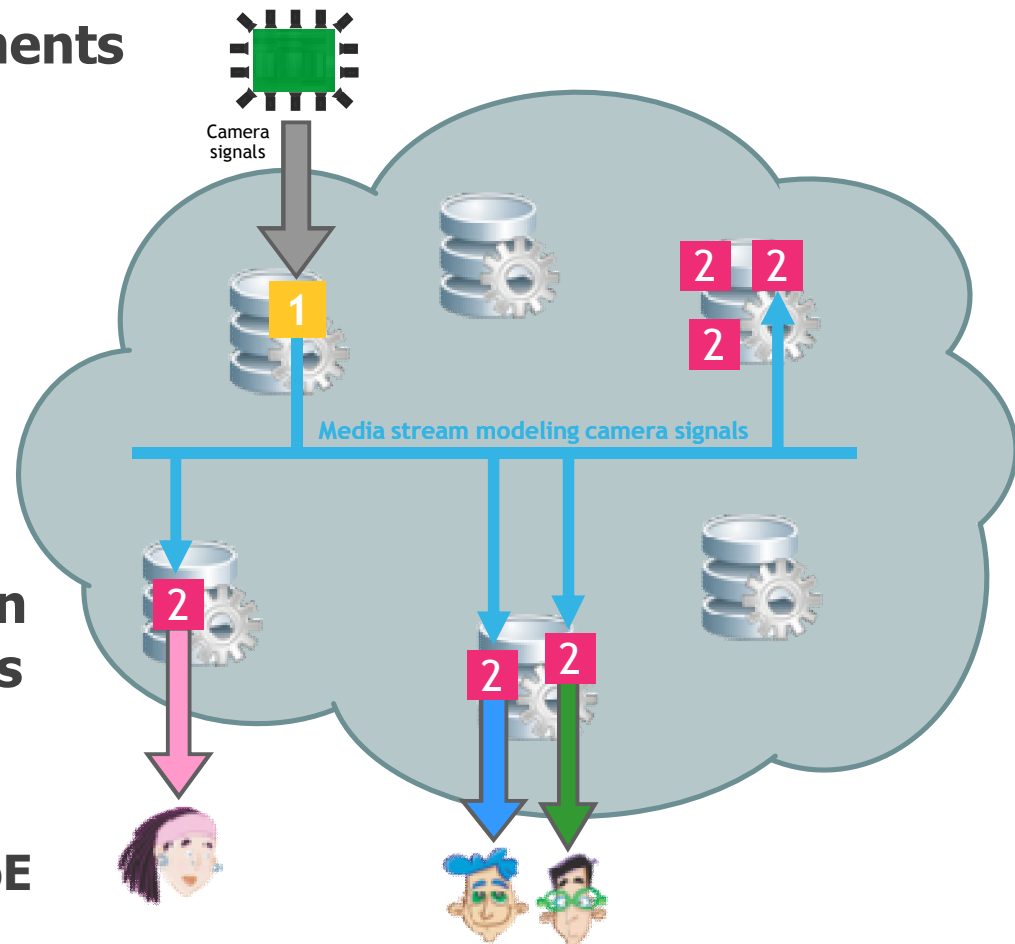## Realizing the Personal Viewpoint TV use case

Service built from components

| 1 | Scene analysis and model calculation |

| 2 | Personalized view rendering (terminal aware) |

Instantiate components on 'appropriate' resources

- **Offloading the network by localizing traffic**
- **Providing best possible QoE**

Camera signals

Media stream modeling camera signals

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Bell Labs Research: Media Cloud

Global resource optimization

Goal: Offloading networks by localizing traffic and providing best possible QoE by exploiting highly distributed global resources
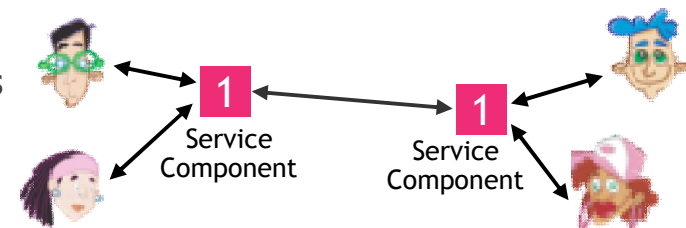
- **Service characteristics description**
  How to achieve 'educated' service (component) deployment strategies

- **Resource discovery & selection**
  How to discover the currently best fitting resources in a global, heterogeneous and heavily distributed resource pool

Building media services from components

Goal: Work out fundamental basis for Media Cloud

- Services built from components operating on media streams

- Resource independent service description and composition

- Media coding schemes for component based processing

- Beyond IP addressing schemes (CCNx inspired concepts...)

- Execution framework for media processing components

Service Component

Service Component

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AT
THE
SPEED
OF
IDEAS