

## Is the dreaded 'Killer-App' back?

#### - the path to Society Scale Cyber-Physical Systems

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## **The Networked Society**

 from the "Internet of Information" to Socitety Scale Cyber-Physical Systems







#### "The Internet of Sensors & Big Data"



Information collected everywhere Enormaous data volumes – "Big Data" Data Mining, "Analytics" for decision support



#### "The Internet of Control"



www.davincisurgery.com





#### **Cyber-Physical Systems (CPS)**



Small scale – stand-alone "Embedded systems"



Networked, Societal Scale CPS





## Scalabilty

- what we have done right so far





#### Scalability - why is it important?



- Large benefits from Digitalization
- Millions of dollars at stake
- Low volumes
- Tailor-made ("hand-crafted") solutions

- Small benefits from Digitalization
- 10s of dollars at stake
- Multiple solutions require own infrastucture
- Massive volumes
- Standardized solutions required





## **Standards & Dominant designs**









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Dominant designs in ICT

- Flexible
- Multi- purpose
- Multi-vendor

Roadkills

- Single purpose ("one trick ponies)
- Few vendors



## **Dominant design of ICT**

- Internet access + Cloud based solution = the Dominant Design for all application involving communication – since 2007 also on mobile
- Simple interface IP for all "apps" creates explosive growth – works on all platforms
- SDN/Virtualization new tools to solve the same problem
- Inefficient for (almost) all applications: we buy flexibility at the expense of large data volumes data



Transparancy eats Efficiency for Breakfast!



#### Extremistan IRL: Mobil ICT



- Standardized platforms: all Android & Apple smartphones behave in same way, everywhere
- English "lingua franca"
- Billions of potential custromers can be reaches in minutes through the Appstrore finns på "app store"
- Millions of "app"-developers



wireless



## Can we repeat the success for CPS ?

- with a scalable network platform, a.k.a. "5G"





# Do the key factors for success of internet & smartphone services apply to IoT and cyber-physical systems ?

- Dominant design in computing and communication platforms ("Cyber World")
- "Free" internet access
- Affordable equipment
- Common standardized platforms for the "Physical world"





#### Is there an "IP-Hourglass" for CPS ?











#### Very diverse infrastructure requirements





Requirement	Human centric	Machine Type
Capacity	Very Large	Small
Number of devices	Moderate	Very large
Wide area coverage	Important	(Sometimes) Important
Reliability	Moderate	(Sometimes) High
Cost	Moderate	(Sometimes) Very low
Power consumption	Moderate	Sometimes) Very low
Delay	Moderate	Sometimes) Very low





#### **Distribution of resources** Intelligence inside, outside or both ?







### **Everything under one roof ?** Transparancy vs Efficiency





#### The IP-access world

- Large volumes of standardized equipment, unified platforms
- Low efficiency, overprovisioning of resources
- Willingness to pay for flexibility

#### The MTC world

- Large volumes
- Very diverse requirement on power, delay, cost, reliability
- Non-standardized equipment, no unified platforms
- Rational decisions based on savings





## Is the 5G/ NR Air interface & NFV/SDN solving these problems ?



Deals only with Air-interface performance



Virtualization

- is costly performance-wise
- can only "redistribute" performance

- · still relies on statistical averaging
  - congestion will affect all



#### **Transparency vs Performance**



High performance Low Delay QoS Guarantees Resource efficient Single purpose "Hardware" defined





#### Infrastructure for CPS - Quo Vadis ?



#### Billion Dollar Question: What is "Sufficient" Performance & Flexibility ?



#### Safety - of - life







#### **Big Data & The Cloud**



#### **DATA - The new natural resource**

- Exabyte, Petabytes stored every year...
- "Everything becomes accessible everywhere
- "Analytics", "Machine Learning",
  "AI" = Harvesting

#### **Business models & Interfaces ?**



#### Conclusion

#### Networked, Society-Scale Cyber-Physical systems

- The next leap in digitization of society from millions to billions of users and devices
- A new generation of **standards & interfaces**
- The dominant ICT solutions only scalable to meet part of the requirements
- A new infrastructure, incremental improvement
   or keep the same ?
- Business models for "Big Data"

