DISTRIBUTING THE SYSTEMS

DYNAMIC NETWORK ARCHITECTURES, AND APPLICATIONS

TNO innovation for life

R.J.MEIJER@UVA.NL AND ROBERT MEIJER AND ROBERT.MEIJER@TNO.NL

1991 – KPN Research, 2003 – TNO, 2002 – University of Amsterdam

University of Amsterdam:
Applied Sensor Networks
Software Defined Networks
Distributed computing

Lives in Drachten

- 3rd 300m National Championship 2013
- 2nd 300m National Championship 2011

TNO:
Distributed Applications, SDN
Sensor networks,
Digital economy

TNO'S DATA R&D

2007 IJKdijk, 2010 'SpaceDikes'

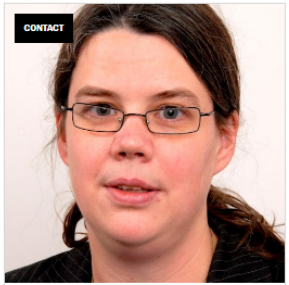
TNO innovation for life

NL CONTACT

FOCUS AREA COLLABORATION ABOUT TNO CAREER TNOTIME

- EXPERTISE
  - Earth, Life and Social Sciences
  - Technical Sciences
  - Early Research Programme
- FIND A TNO EMPLOYEE
- PARTNERS OF TNO
- PATENTS AND LICENSES
- HOW WE WORK
- TNO AND SME'S
- TNO IN EUROPE

CONTACT



DR. JUDITH DIJK

Location The Hague - Oude Waalsdorperweg

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CONTACT US

MAKING SENSE OF BIG DATA

Big Data is an all-encompassing term that stands for any collection data set so large and complex that it becomes too difficult to process using on-hand data management tools or traditional data processing applications. The topics of this program are 1) creating value, 2) extracting meaning and 3) distributed data structures. We will focus on two fields where we expect Big Data methods to be a game changer: Logistics and Personalized health.

Three roles in Big Data eco system (from European Big Data Value cPPP)

Big Data is an all-encompassing term that stands for any collection data set so large and complex that it becomes too difficult to process using on-hand data management tools or traditional data processing applications. Although Big Data is in this way formulated as a problem, it holds in fact an enormous potential in various fields, ranging from health, food security, climate and resource efficiency to energy, intelligent transport systems and smart cities; an opportunity which we cannot afford to miss.

Although the topic is clearly general and relevant for a wide range of domains, we will focus on two fields where we expect Big Data methods to be a game changer: Leagile logistics and personalized health.

Three main roles can be identified in the big data ecosystem: data provider, data processor and service provider and service consumer, see figure. We adopt this picture to define three main technology lines: creating value, extracting meaning and distributed data infrastructures.

ACTIVITIES

Big Data innovations demand new types of collaboration. In Creating Value we investigate the value of new big data applications (and the individual elements of the value creation process of data), the context in which this value is created and the broader potential economic and societal impacts

CGW Workshop '16

Kraków, Poland
October 24-26, 2016

10:40 - 11:10 *coffee and posters*

11:10 - 12:50 Session S2, *Chair: Krzysztof Zieliński*

R. Brzoza-Woch, M. Konieczny, B. Kwolek, P. Nawrocki, T.

onitoring and **flood**
Harężlak, M.
T. Gubała, M. Malawski,

ıution inside the
ka-Belniak, M. Dwornik,

onitoring experimental
A. Borecka, K. Korzec,

12:50 - 14:10 *l*

14:10 - 16:00 S

opple, 2) Krakow

ɔn for **flood**
M. Chuchro,

om experimental **flood**
ek, A. Leśniak

M. Seleng, L. Hluchý

5. **Detection of malicious behavior of mobile devices using**

6. **Influence of initial water saturation in earthen levee on results of numerical modelling of infiltration process,**

THE COMPUTER SCIENCE OF DIKES

- Ideally stupid: $\sum_i F_i \sim 0$
  - Information science
    - How to generate a multiscale phenomenology?
  - Large scale computing:
    - How to generate the two differential equations from 3D+T simulations
  - System identification:
    - How to detect new degrees of freedom
  - Distributed systems
    - How to generate the ICT for 1000's km of monitoring infrastructure


8 QUOTES THAT WILL
MOTIVATE YOU TO
MAKE A PLAN AND STICK TO IT


NO EXCUSES
CELSIUS


STICK TO THE PLAN


STICK TO THE PLAN

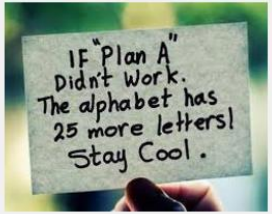

STICK WITH THE
PLAN.
Joel Brackenstein


PLAN AHEAD


KEEP
CALM
Stick With The Plan
AND NO ONE
GETS HURT


I COULD RULE THE WORLD.
BUT I CAN'T STICK TO
ONE PLAN FOR MORE THAN
36 HOURS.


Plan A.
Because there
is no Plan B.


IF "Plan A"
Didn't Work.
The alphabet has
25 more letters!
Stay Cool.


For my part I know
nothing with any
certainty, but the sight
of the stars makes me dream.


STICK TO THE
PLAN!
DAYZ


GET GOAL
MAKE PLAN
GET TO WORK
STICK TO IT
REACH GOAL


STICK TO THE PLAN


ABCDEFGHIJKLM
NOPQRSTUVWXYZ
abcdefghijklm
nopqrstuvwxyz
0123456789!?#


I SHOULD STICK
TO THE PLAN.


DUDE, STICK TO
THE
ORIGINAL PLAN


The HARDEST BUT MOST
IMPORTANT thing to do, IS
STICK TO THE PLAN


3.
STICK
TO THE PLAN
man

LEVEE'S ARE IDEAL FOR CS

CGW'16 will address the following topics:

- e-Science, system-level science and collaborative applications,
- data intensive applications and tools,
- models, methods and tools for collaborative applications development,
- virtual laboratories and problem solving environments,
- distributed computing infrastructures (DCI),
- knowledge in e-Science and DCI systems,
- virtual organizations and security aspects,
- monitoring, information and resource management and scheduling,
- software engineering aspects with industrial and social implications.

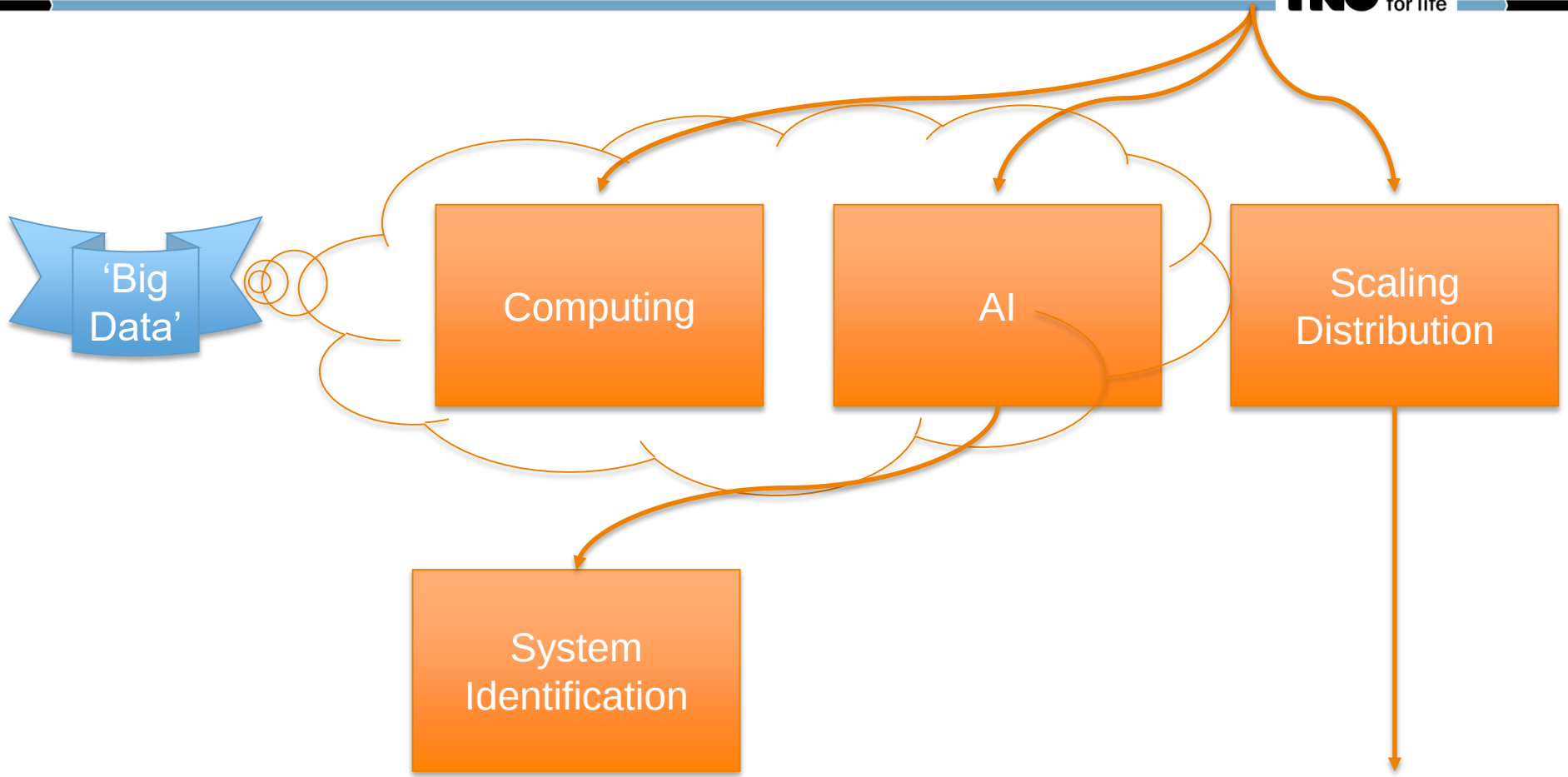
CGW'16 will also be an opportunity to present scientific and technical achievements as well as to overview research in related national and European projects.

LARGE SCALE DISTRIBUTED SYSTEMS
FP7 – URBANFLOOD – 'EXCELLENT'

Computing

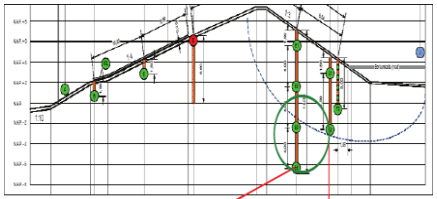
AI

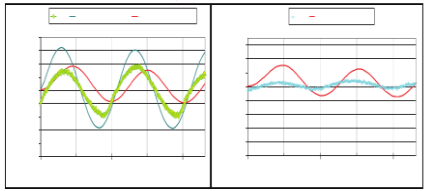
Scaling
Distribution

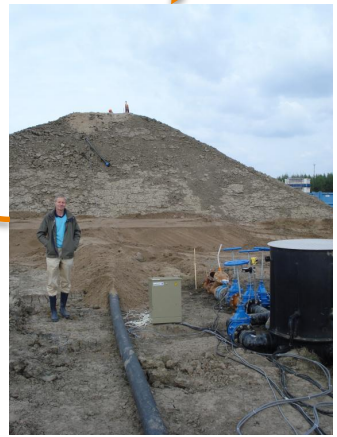

‘Big Data’
Computing
AI
Scaling Distribution
System Identification

SYSTEMS IDENTIFICATION IN FP7 URBANFLOOD

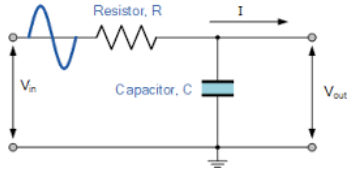
TNO innovation for life

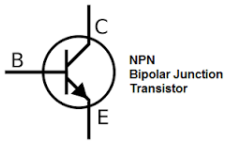






Scaling
Distribution





Generic
System
Identification

TAKE AWAY:

LARGE SCALE SENSOR NETWORKS

LARGE SCALE SYSTEMS MODELLING

DYNAMIC NETWORKED ARCHITECTURES, AND APPLICATIONS

TECHNOLOGY FOR HIGH TECH APPLICATIONS

PROF DR ROBERT MEIJER – TNO, UVA

TNO innovation for life

R&D UNIVERSITY OF AMSTERDAM & TNO
CONCEPTS TO GENERATE ICT INFRASTRUCTURE

INTERNET FACTORIES

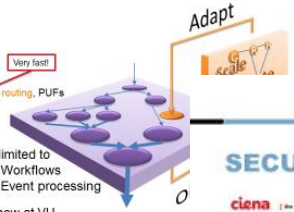
Software Defined Infrastructures
- Generation
- Adaptation
- Linking
- Globally

PhD 2014 UvA, Rudolf Strijkers, now at Swisscom

SCALING AND DISTRIBUTION OF ICT

Scaling and distribution
1. Scale
2. Distribute
3. Best paths, free flows, GPU's for routing, PUFs
4. Globally, continuously

Very fast!

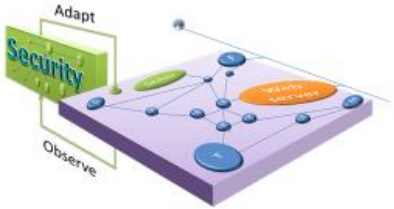


Is limited to
- Workflows
- Event processing

PhD 2016 UvA, Marc Makkes, now at VU

SECURITY ADAPTIVE RESPONSE NETWORKS

Security of ICT
- SARNET: Security adaptive response networks
- Virtual and real (fiber) networks



PhD UvA 2019, Ralph Koning,

R&D UNIVERSITY OF AMSTERDAM & TNO
FUTURE INFRASTRUCTURE RESEARCH

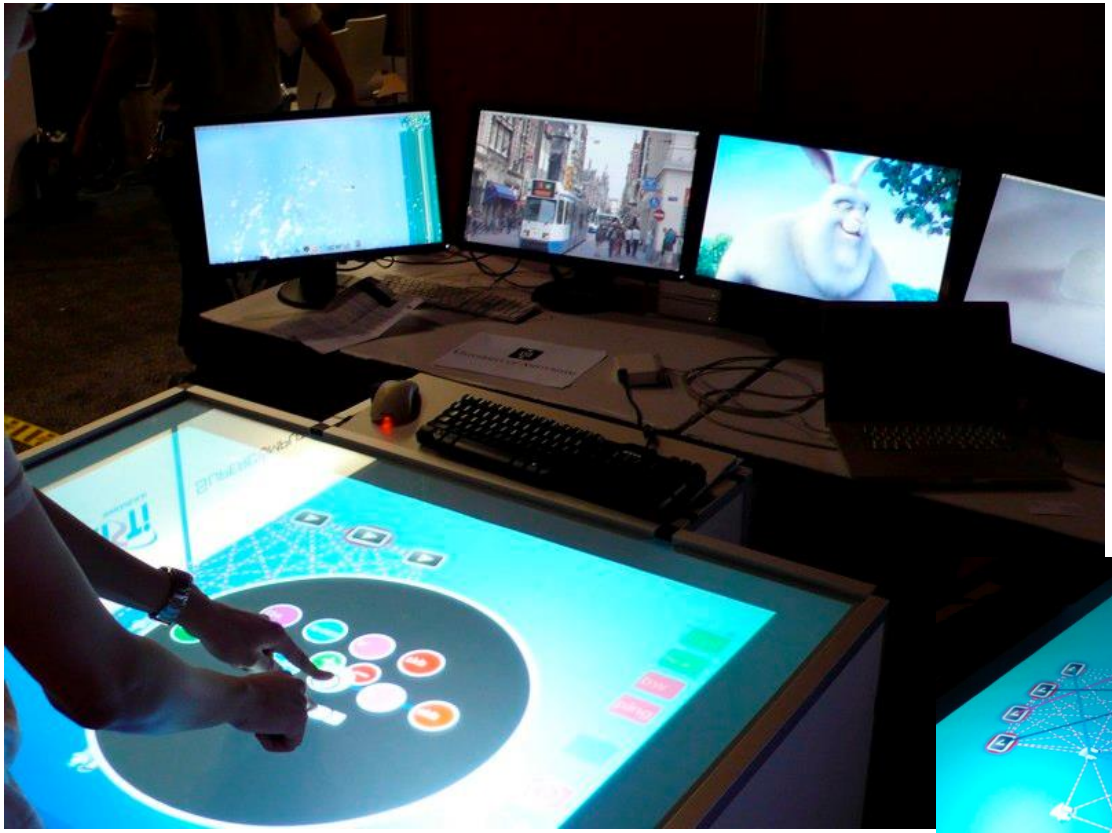
SDN? Smart cars and their usage of 5G WIFI-P networks

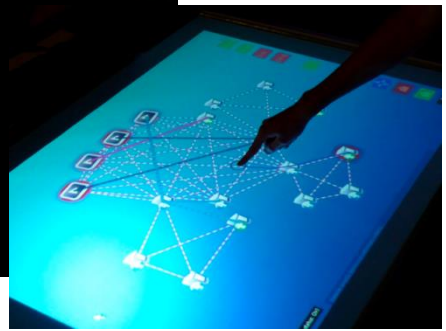
Master BsC 2016
TU Ilmenau (Germany),
Adarsh Nayak

DNA software – Dynamic Networked Architectures

PhD
2012-2015 UvA / TNO,
Jan Sipke van Der Veen

VIDEOS





http://youtube.com/user/ciosresearch

1 world wide wide

2 programming and compiling

3 it works

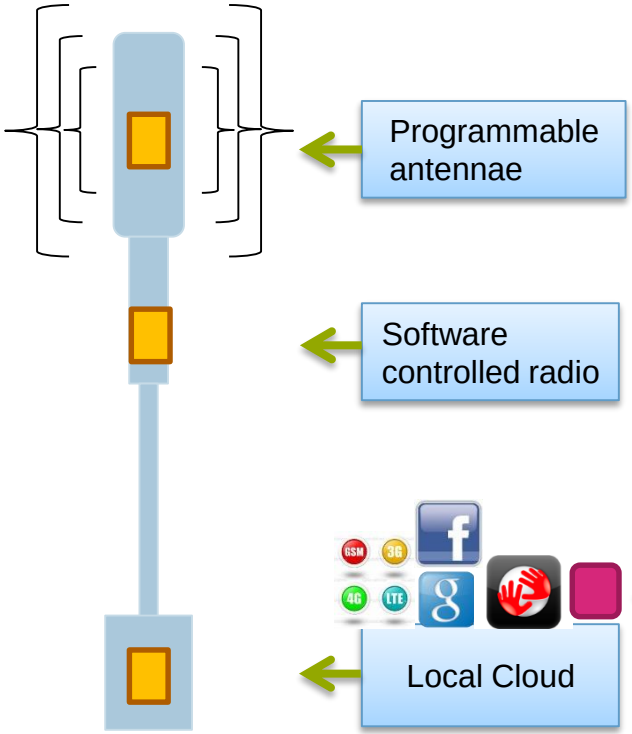
4 feedback

5 feedback world

6 SARNET reliability

(CONCEPTS OF) EXTREME “SOFTWARIZATION”

- OSI Layers 1,2,3,4,5,6 under app control



Fixed Software

Self Distributing Software

TAKE AWAY:

FROM

SOFTWARE DEFINED **INFRASTRUCTURE**

TO

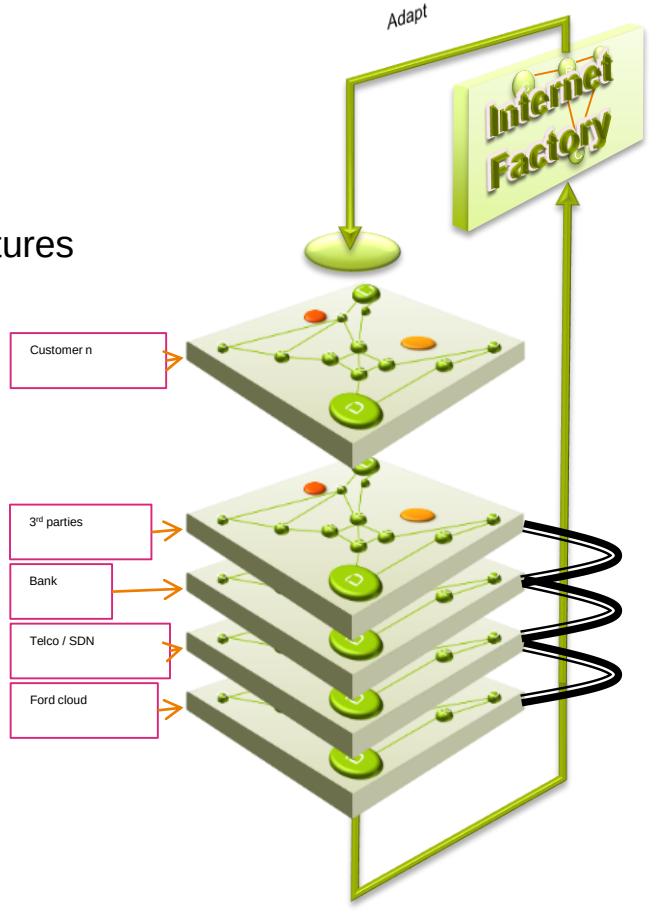
SOFTWARE DEFINED **INTERNET OF THINGS**

INTERNET FACTORIES

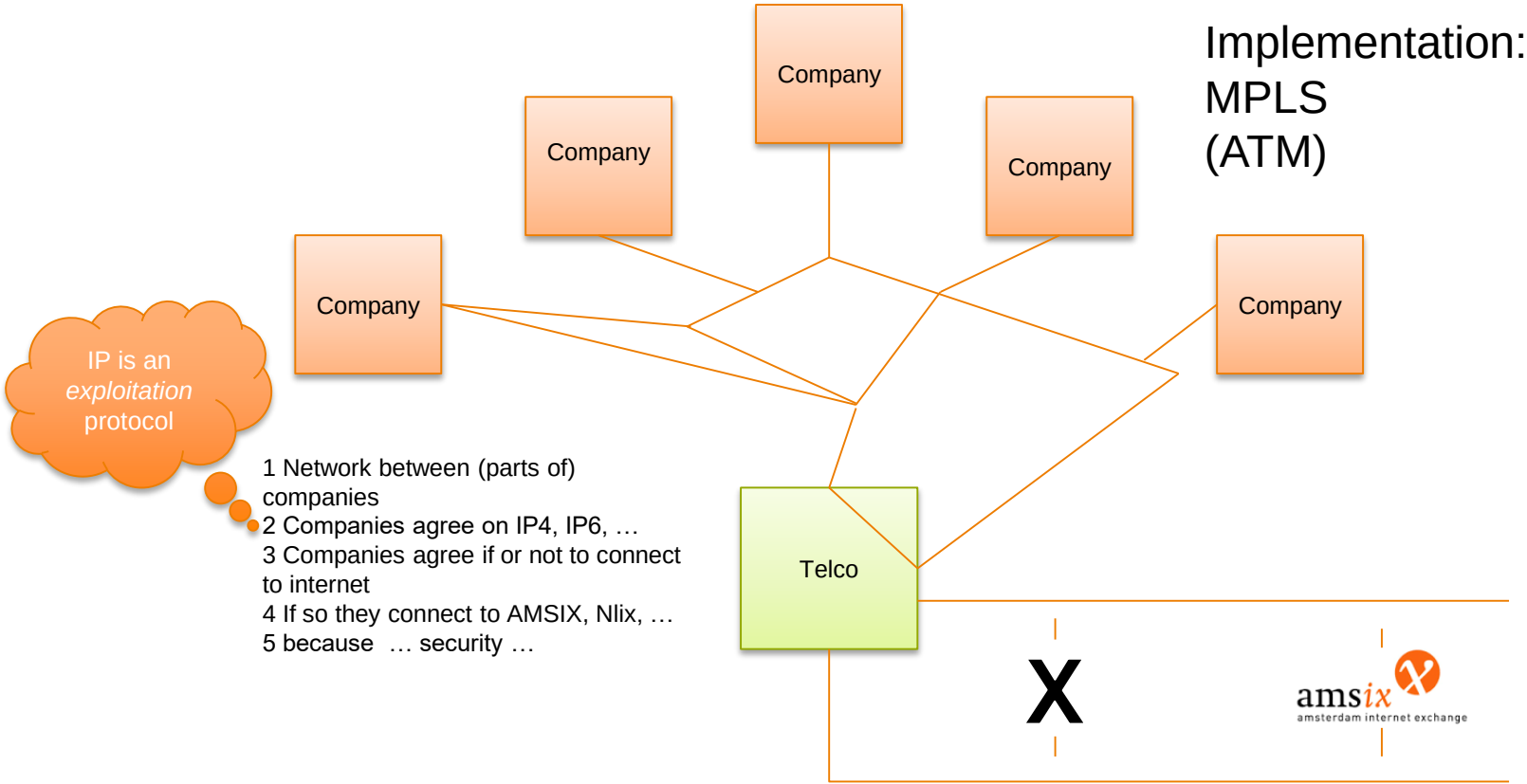
Software Defined Infrastructures

- Generation
- Adaptation
- Linking
- Globally

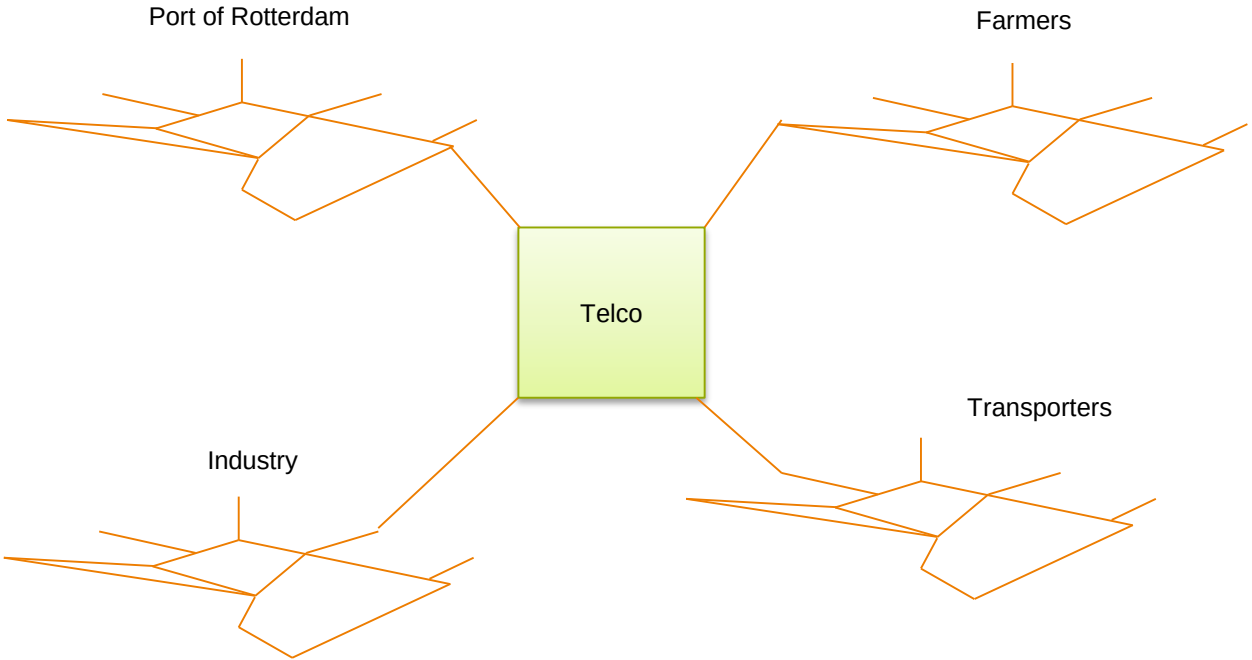
PhD 2014 UvA, Rudolf Strijkers,
now at Swisscom

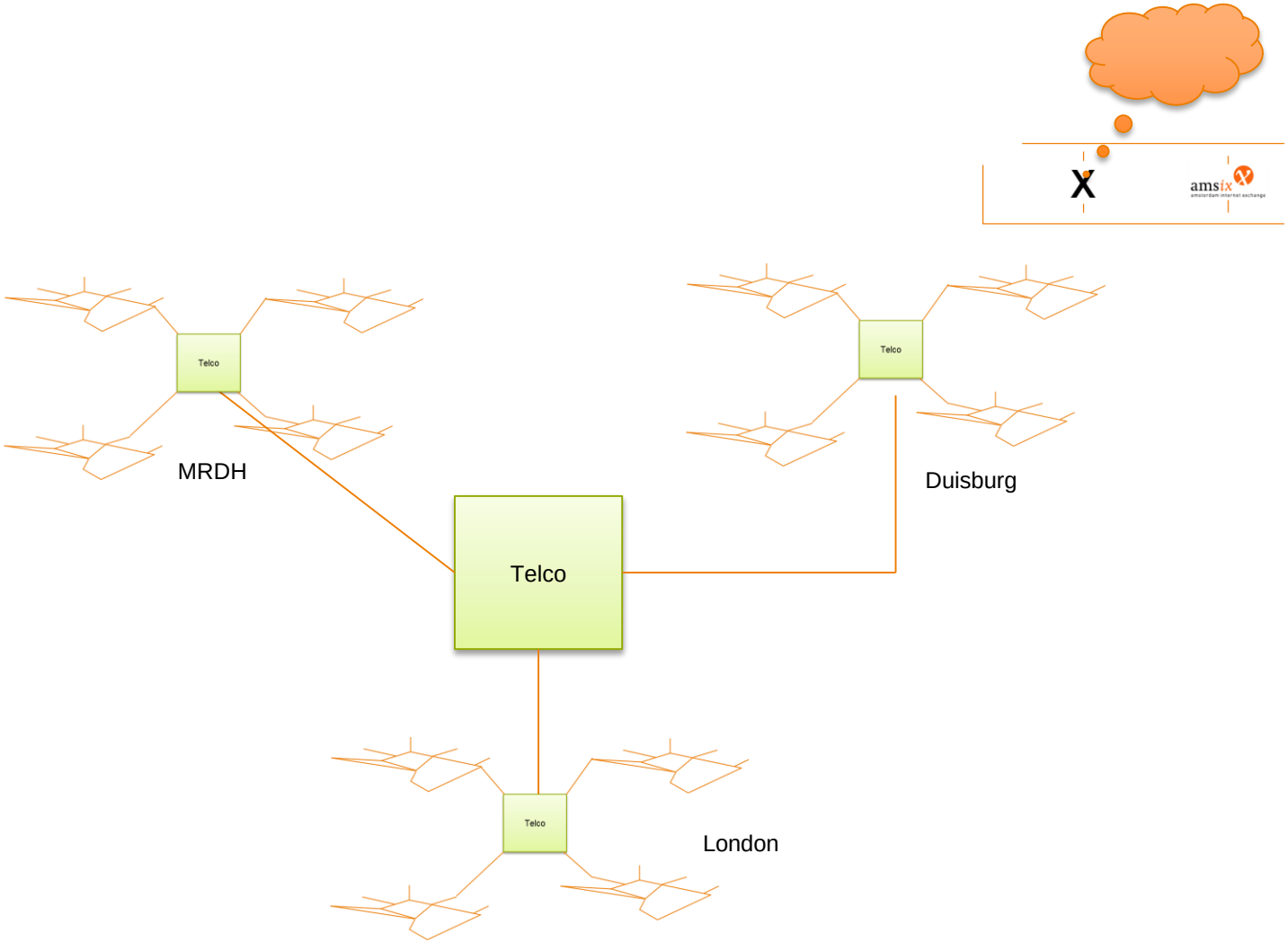


STARTING POINT:
TRADITIONAL VIRTUAL PRIVATE NETWORKS

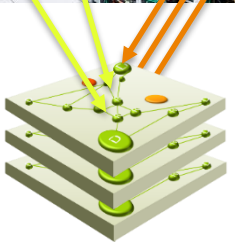


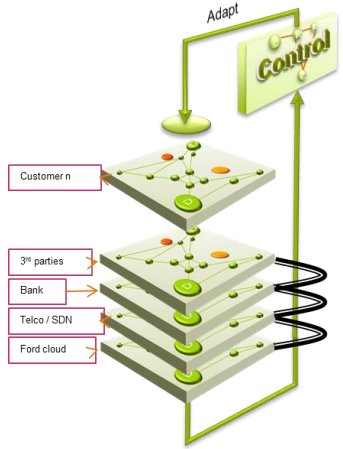
NETWORK OF SECURED NETWORKS

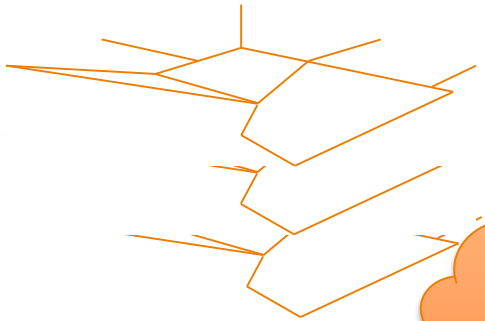



amsix
Telco
MRDH
Telco
Duisburg
Telco
Telco
London

NETWORK IN THE CLOUD



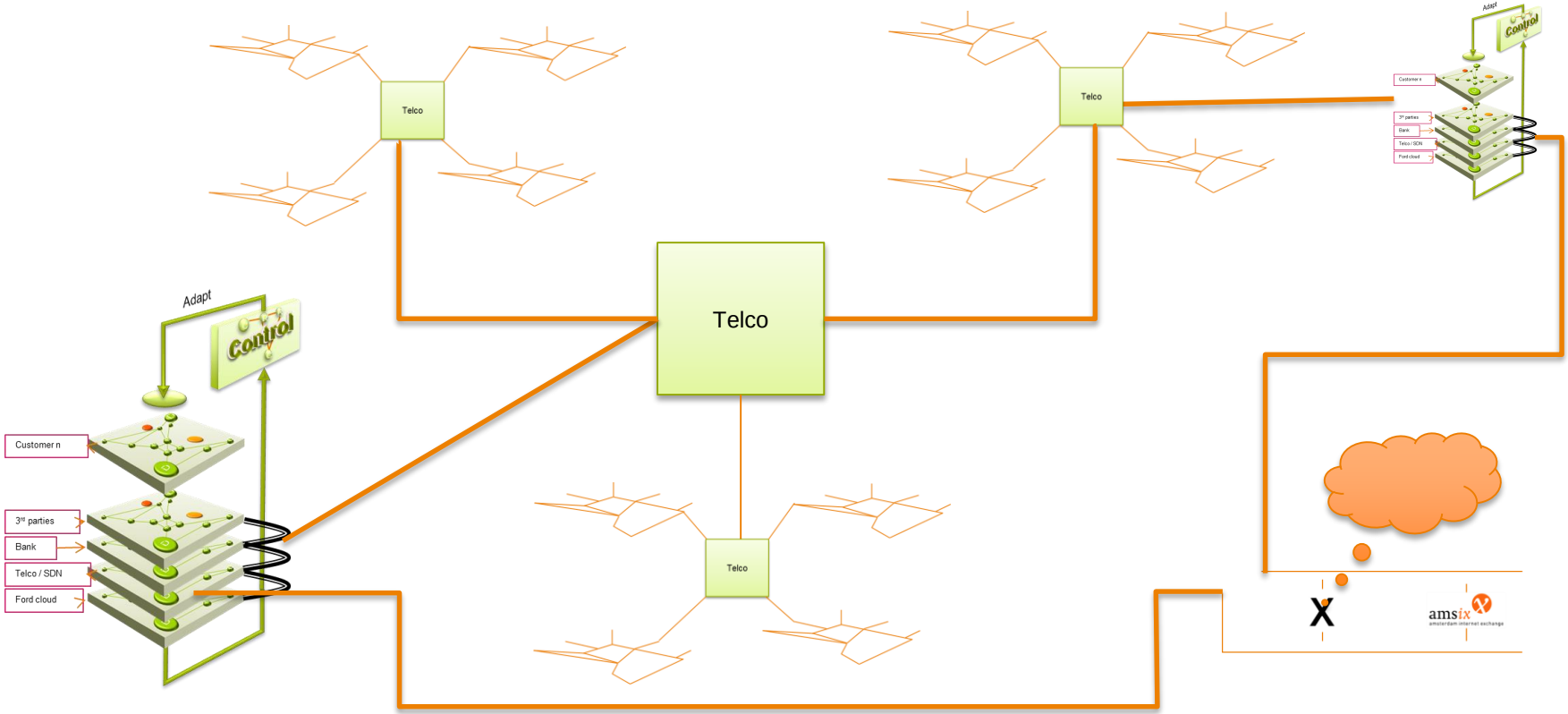




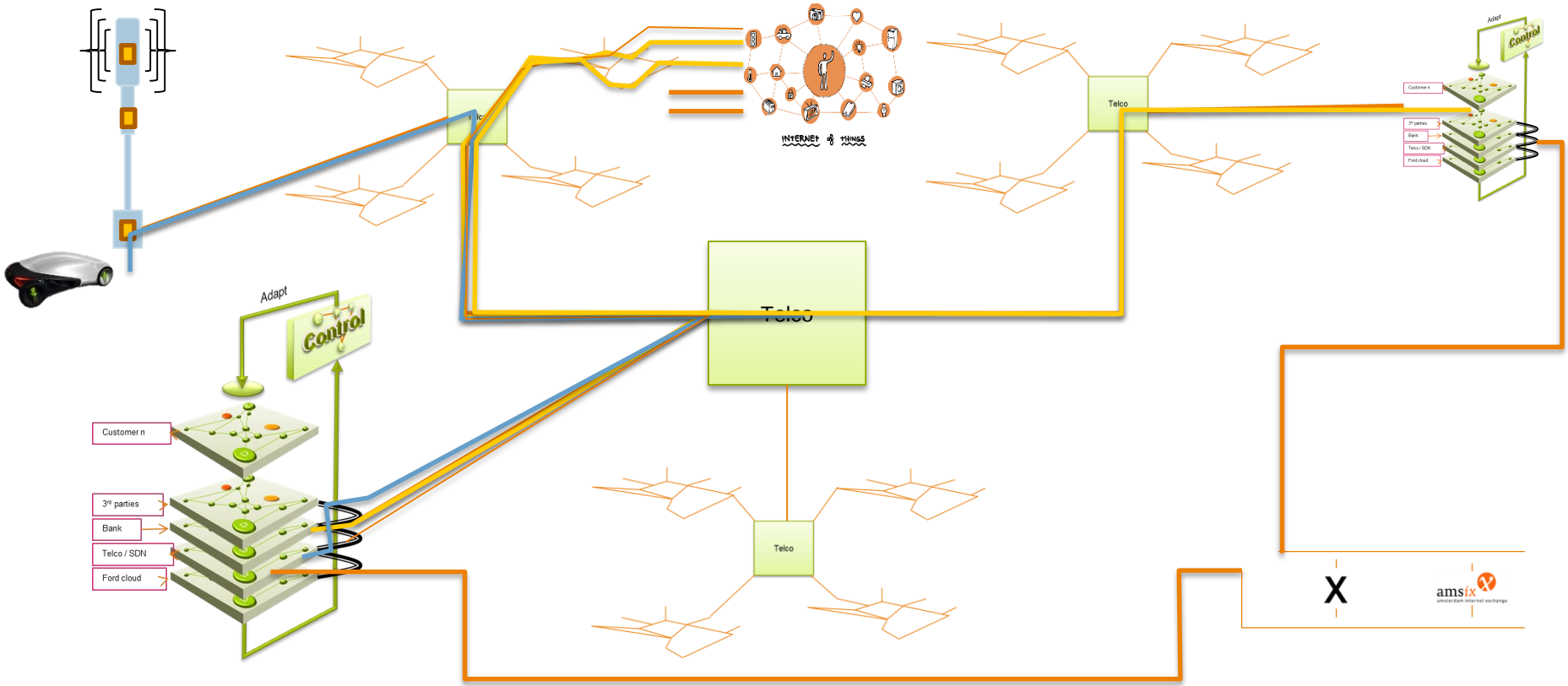
IPv6
ideal for
clouds

PhD 2014 UvA, Rudolf Strijkers, now at Swisscom

INTERWORKING OF SOFTWARIZED AND REAL ICT



INTERWORKING OF SOFTWARIZED AND REAL ICT



TAKE AWAYS

INTERNET WILL BE DISTRIBUTED TO THE CLOUD

IPV6 ‘IDEAL’ FOR CLOUD NETWORKS

SECURITY TROUGH ARCHITECTURE

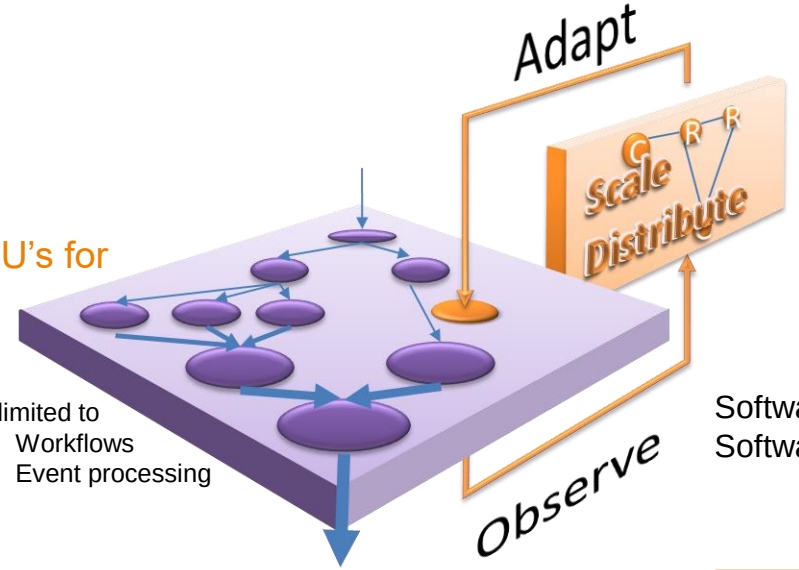
SCALING AND DISTRIBUTING
SOFTWARE DEFINED INFRASTRUCTURE

SCALING AND DISTRIBUTION OF ICT

Scaling and distribution

1. Scale
2. Distribute
3. Best paths, free flows, GPU's for routing, PUFs
4. Globally, continuously

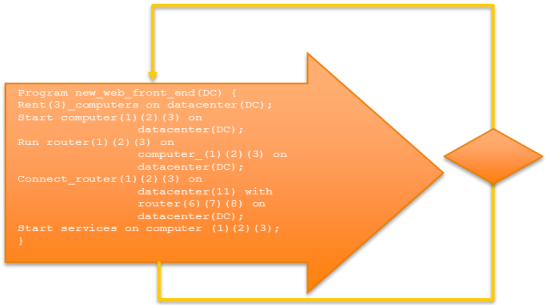
Marc Makkes,
PhD 2016 UvA,
now at VU



Is limited to

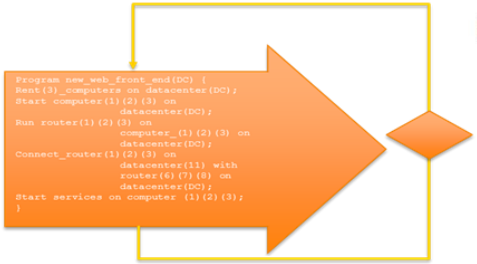
- Workflows
- Event processing

Software controlled network + computer
Software controlled ICT



SCALING AND DISTRIBUTION ROUTING, NETWORKS, INFRASTRUCTURE

Software controlled network + computer
Software controlled ICT



Fast Packet forwarding Engine Based on Software Circuits

Marc X. Makkes
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Cees de Laat
University of Amsterdam
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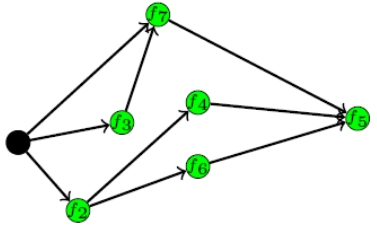
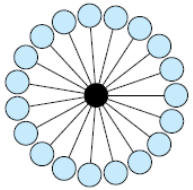
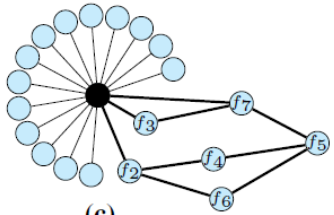
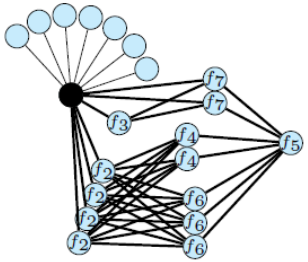
```
__kernel void
bitslice(__global unsigned int *i, __global unsigned int *r)
{
 int id = 24 * get_global_id(0);
 int rid = 2 * get_global_id(0);

 // 2.104.63.0/14 => 00000010011010, if = 1
 unsigned int p0 = (~i[id + 0 ]) & (~i[id + 1 ]) & (~i[id + 2 ]) & (~i[id + 3 ]) & (~i[id + 4 ]) & (~i[id + 5 ]) & i[id + 6] & (~i[id + 7 ]) & \\
     (~i[id + 8 ]) & i[id + 9] & i[id + 10] & (~i[id + 11 ]) & i[id + 12] & (~i[id + 13 ]);

 // 29.247.95.0/15 => 000111011111011 if = 1
 unsigned int p1 = (~i[id + 0 ]) & (~i[id + 1 ]) & (~i[id + 2 ]) & i[id + 3] & i[id + 4] & i[id + 5] & (~i[id + 6 ]) & i[id + 7] & \\
     i[id + 8] & i[id + 9] & i[id + 10] & i[id + 11] & (~i[id + 12 ]) & i[id + 13] & i[id + 14];

 // 89.176.76.0/20 => 01011001101100000100, if = 3
 unsigned int p2 = (~i[id + 0 ]) & i[id + 1] & (~i[id + 2 ]) & i[id + 3] & i[id + 4] & (~i[id + 5 ]) & (~i[id + 6 ]) & i[id + 7] & i[id + 8] & \\
     (~i[id + 9 ]) & i[id + 10] & i[id + 11] & (~i[id + 12 ]) & (~i[id + 13 ]) & (~i[id + 14 ]) & (~i[id + 15 ]) & (~i[id + 16 ]) & i[id + 17] & \\
     (~i[id + 18 ]) & (~i[id + 19 ]);

 r[ rid + 0] = p0 | p1 | p2;
 r[ rid + 1] = p2 ;
}
```

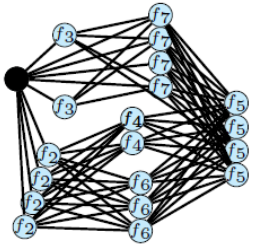
Figure 2: Example of an generated kernel for 3 prefixes and 3 nexthops





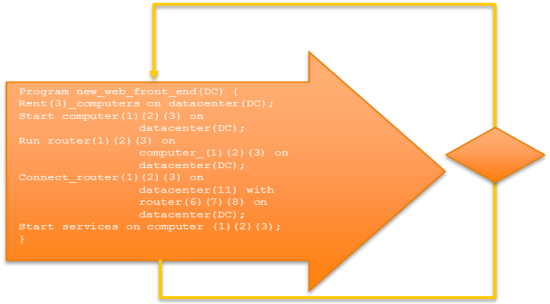






GLOBAL DISTRIBUTED NETWORKS AND SOFTWARE SYSTEMS

- QoS > Internet
- Supporting adaptive workflow systems



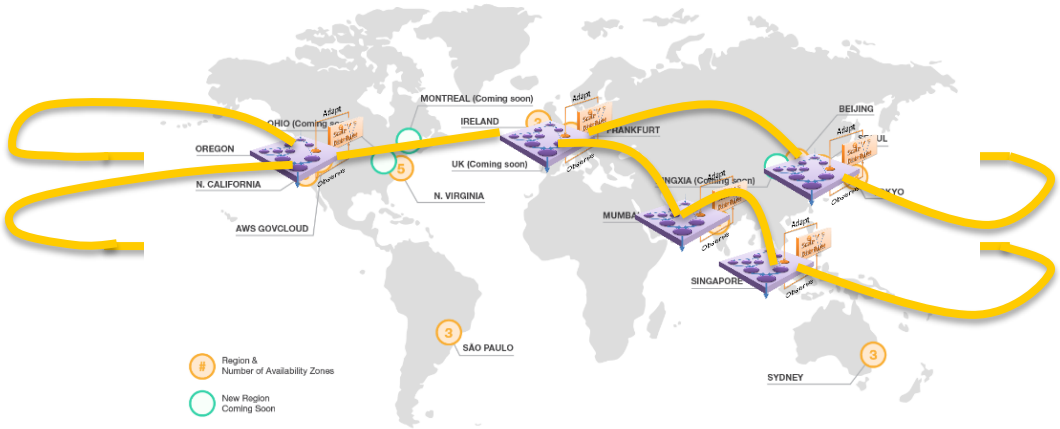
AWS Global Infrastructure

The AWS Cloud operates 35 Availability Zones within 13 geographic Regions around the world, with 9 more Availability Zones and 4 more Regions coming online throughout the next year.

AWS Regions and Availability Zones

The AWS Cloud infrastructure is built around Regions and Availability Zones ("AZs"). A Region is a physical location in the world where we have multiple Availability Zones. Availability Zones consist of one or more discrete data centers, each with redundant power, networking and connectivity, housed in separate facilities. These Availability Zones offer you the ability to operate production applications and databases which are more highly available, fault tolerant and scalable than would be possible from a single data center. The AWS Cloud operates 35 Availability Zones within 13 geographic Regions around the world.

Global Infrastructure



aws.amazon.com/about-aws/global-infrastructure/

TAKEAWAYS

ADAPTIVE GLOBAL CONNECTIONS WILL RUN VIA CLOUD DATA CENTERS

WORKFLOWS SYSTEMS EXHIBIT EQUILIBRIUM PATTERNS

SECURING

- SOFTWARE DEFINED INFRASTRUCTURE
- DATA
- DIGITAL TRANSACTIONS

SECURITY ADAPTIVE RESPONSE NETWORKS

ciena : the network specialist

AIR FRANCE KLM Royal Dutch Airlines

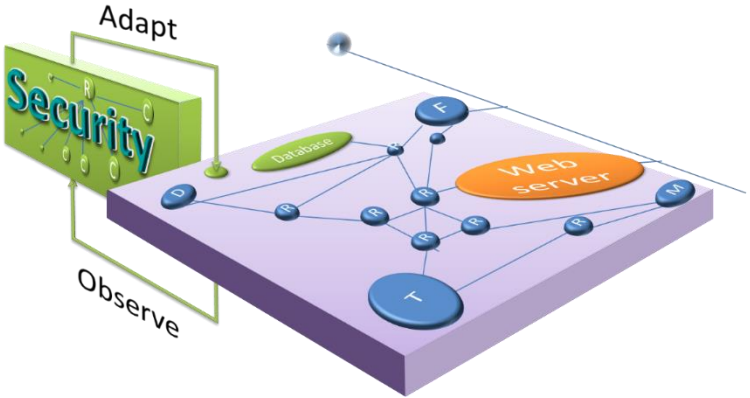
Universiteit van Amsterdam

TNO

PhD UvA 2019, Ralph Koning,

Security of ICT

- SARNET: Security adaptive response networks
- Virtual and real (optical) networks



Interactive Analysis of SDN-driven defence against Distributed Denial of Service attacks

Ralph Koning, Ben de Graaff, Cees de Laat, Robert Meijer, Paola Grosso
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***Abstract*—The Secure Autonomous Response Networks (SARNET) framework introduces a mechanism to respond autonomously to security attacks in Software Defined Networks (SDN). Still the range of responses possible and their effectiveness need to be properly evaluated such that the decision making process and the self-learning capability of such systems are optimized. To this purpose we developed a touch-table driven interactive SARNET prototype, named VNET, and we demonstrated its use through real-time monitoring and control of real and virtualised networks. By observing users interacting with the system at SC15 in Austin, we concluded that in a SDN it is possible to achieve high effectiveness of responses by carefully choosing a relatively minor number of actions.**

I. SARNET FRAMEWORK

Software Defined Networks (SDN) have been proposed as an effective way to build and support secure (network) services. The underlying assumption is that the capability of programming the topology and the paths taken by traffic flows will build stronger and more resilient networks, and provide automated responses in the case of attacks. Therefore, we decided to build a framework that addresses two challenges that are currently not covered by other SDN systems. Firstly, we want to provide a system that can react **autonomously** to attacks by exploiting a knowledge base of tactics tailored to the strategies defined by the businesses that use the system. Secondly, we want to allow services to span **multiple domains** by allowing the definition of joint strategies amongst cooperating organisations.

The SARNET framework [1] will provide autonomous response across multiple domains to network attacks by exploiting the underlying SDNs functionalities and virtualised network functions. The vision is that the SARNET framework will be adopted by enterprises to provide secure (cloud) services. The autonomous response in a SARNET is achieved by means of a control loop, depicted in Fig. 1.

Every SARNET will monitor the state of the network and services by continuously evaluating a number of *security observables*. Detection of violation of the expected state and values of these observables will initiate the control loop. After a recognition phase (*classify, analyse,* and *risk*), a SARNET will autonomously *decide* the appropriate response to bring the network back to an acceptable security state. Adjustments might be needed if the observables do not return to the desired state after responding. A SARNET will reprogram the network flows, redefine the location of the virtualised network functions, and possibly move the location of computing and storage services.

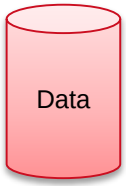
While developing the framework, it is imperative to assess, via fast prototyping, what the implementation issues are, and possibly whether architectural assumptions need revision. Therefore, we set out to investigate:

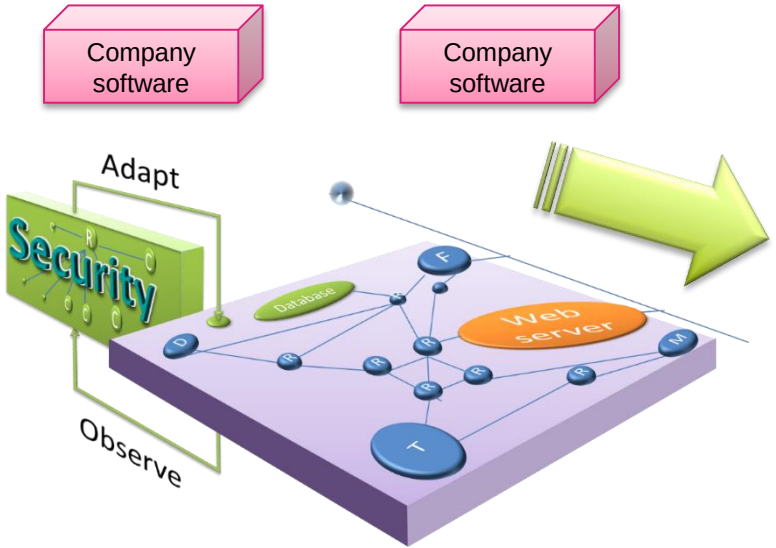
- What is the most appropriate way to expose the security observable to external components, either human or software? Concretely, which visualization techniques are suitable for SARNETs?
- What is the range of responses possible in a SARNET and how do these depend on the underlying SDN control software?
- What are the metrics that can guide the selection of responses to attacks during the *decide* phase, and what are the most valuable metrics we can store in the *learn* phase to determine solutions' effectiveness for future selection?

In this paper, we present the results and findings on the above questions that we obtained with our interactive prototype, where visitors use a multi-touch interface to detect and respond to DDoS attacks, and was demonstrated during the Super Computing conference held in Austin, TX in November 2015 (SC15).

SECURE DATA AND TRANSACTIONS

Ralph Koning
‘ PhD UvA 2019,





SECURITY, DISTRIBUTION AND SCALING COMBINED

Ralph Koning
‘ PhD UvA 2019,

+

Marc Makkes,
PhD 2016 UvA,
now at VU

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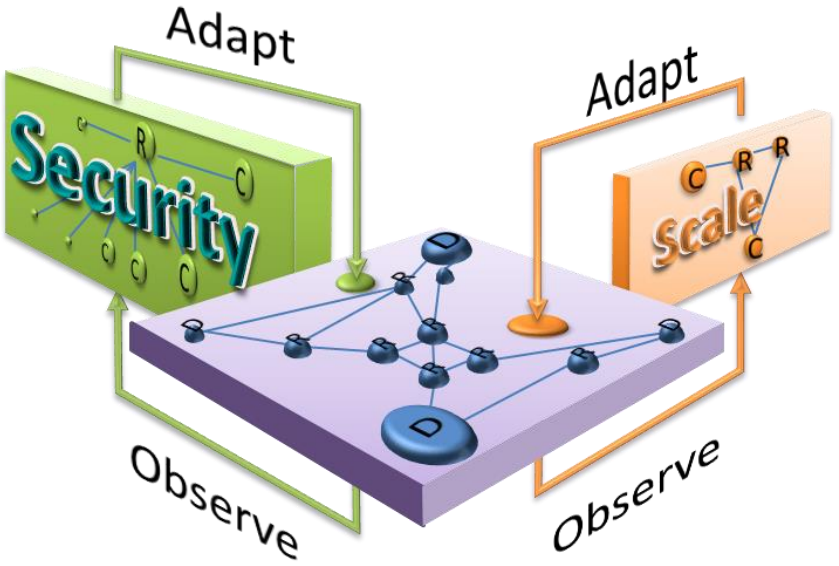
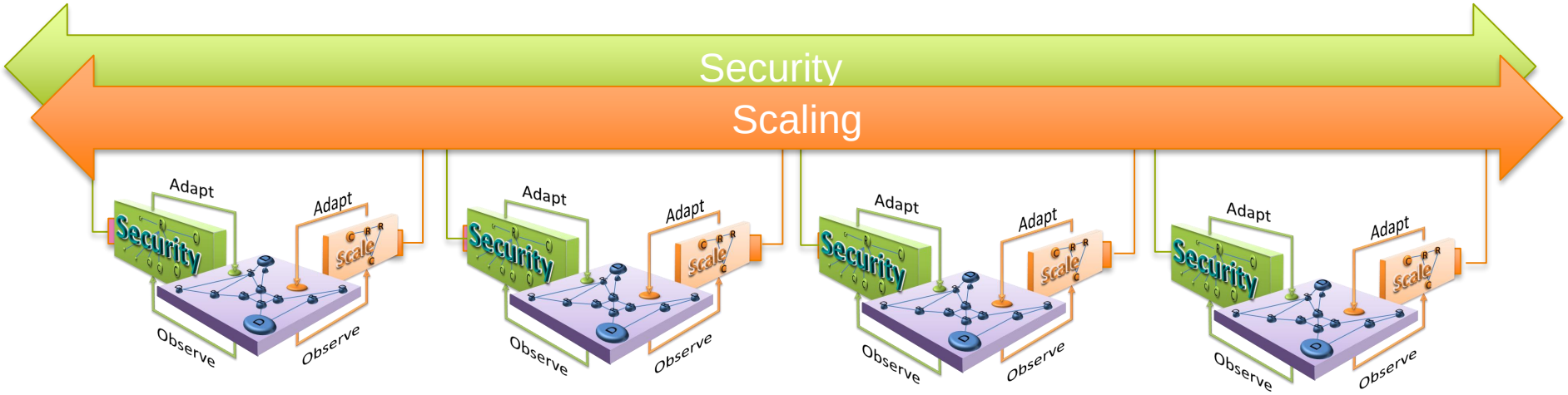


SECURITY SCALING AND DISTRIBUTION AS A SERVICE

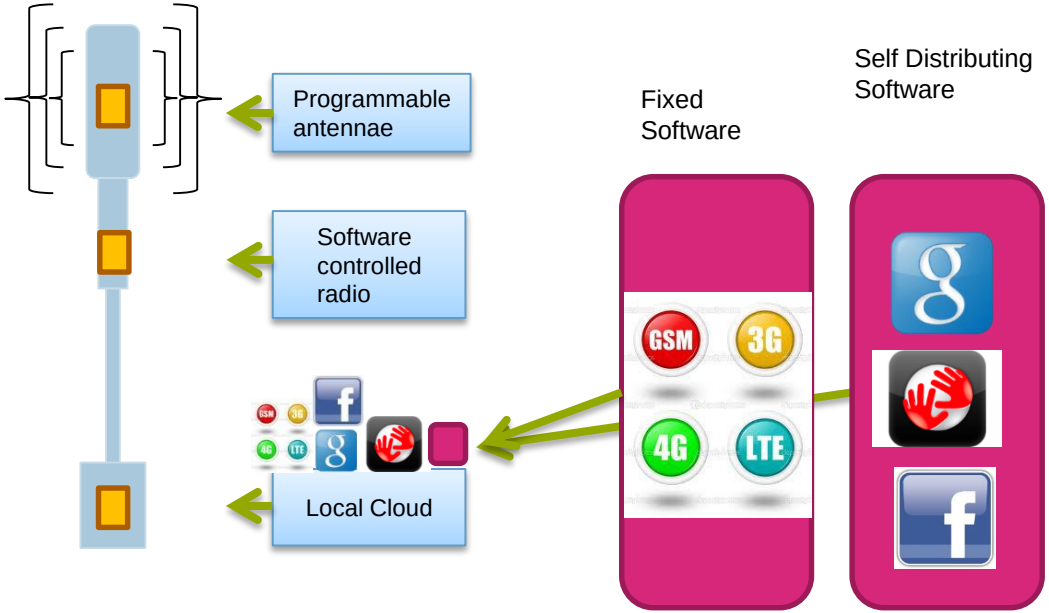


TAKEAWAY

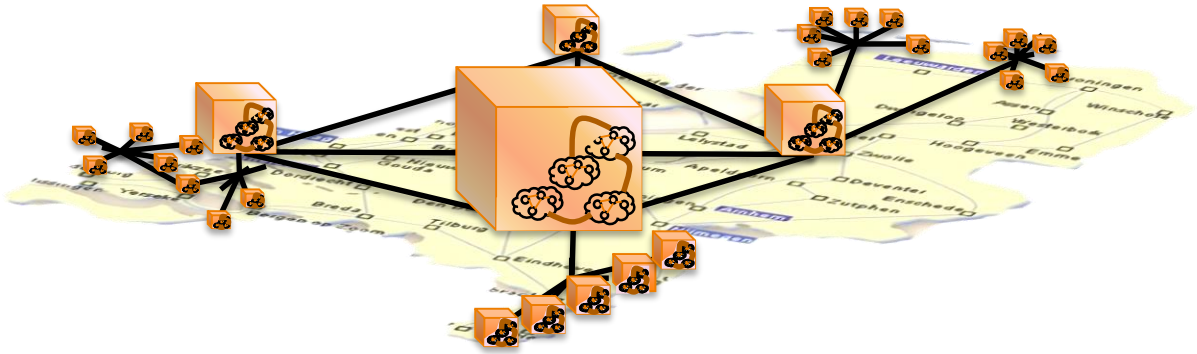
SOFTWARIZATION OF ICT ALLOWS GLOBAL SECURITY SCALING AND DISTRIBUTION SERVICES

TO WHAT DO WE DISTRIBUTE?

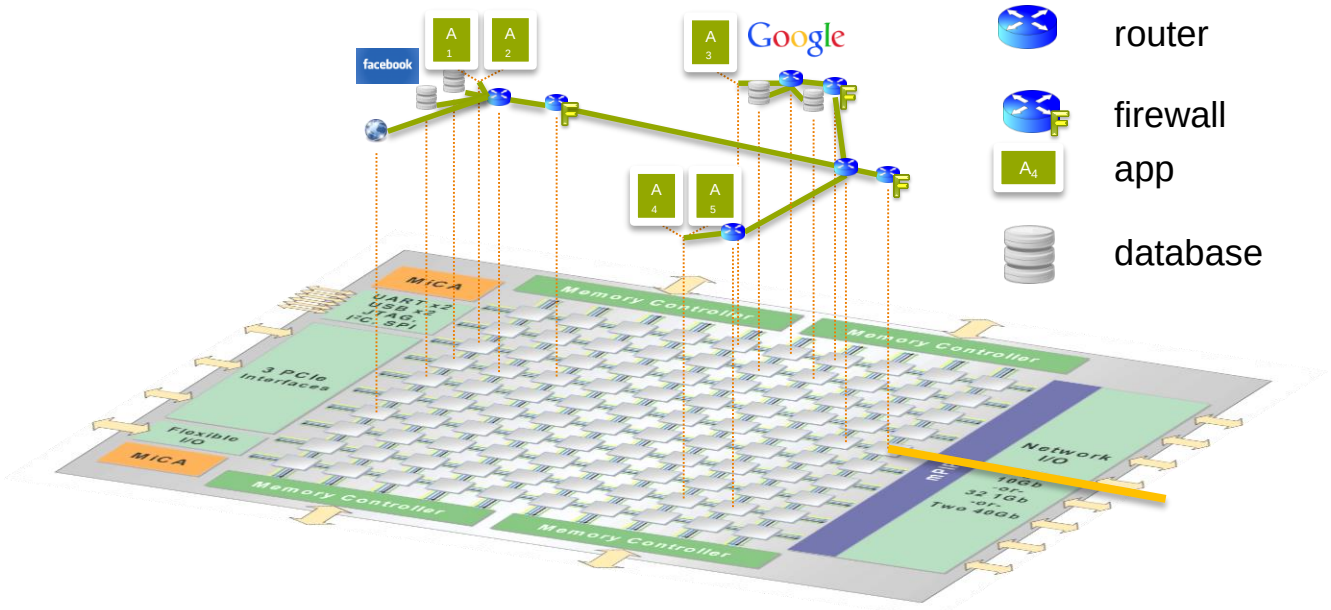
TO EDGE SYSTEMS



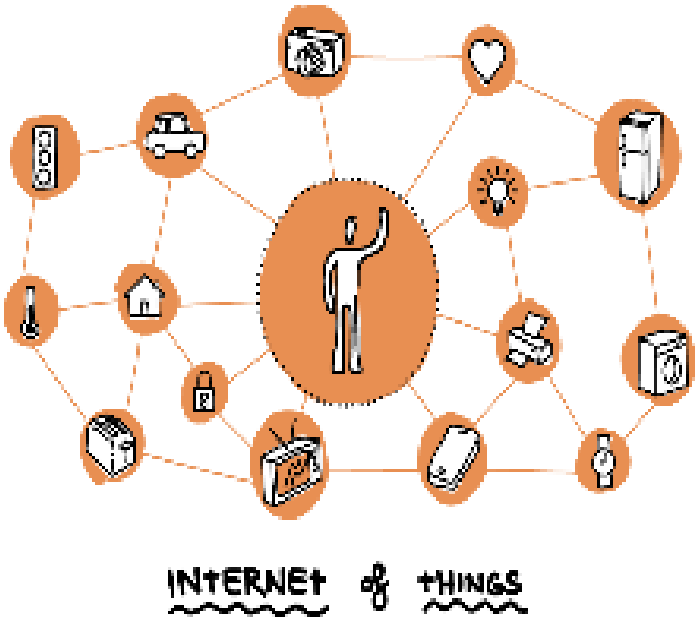
TO A NATIONWIDE, LATENCY ORIENTED, SYSTEM OF DATA CENTERS



TO MULTI CORE CPU'S



TO EVERYTHING

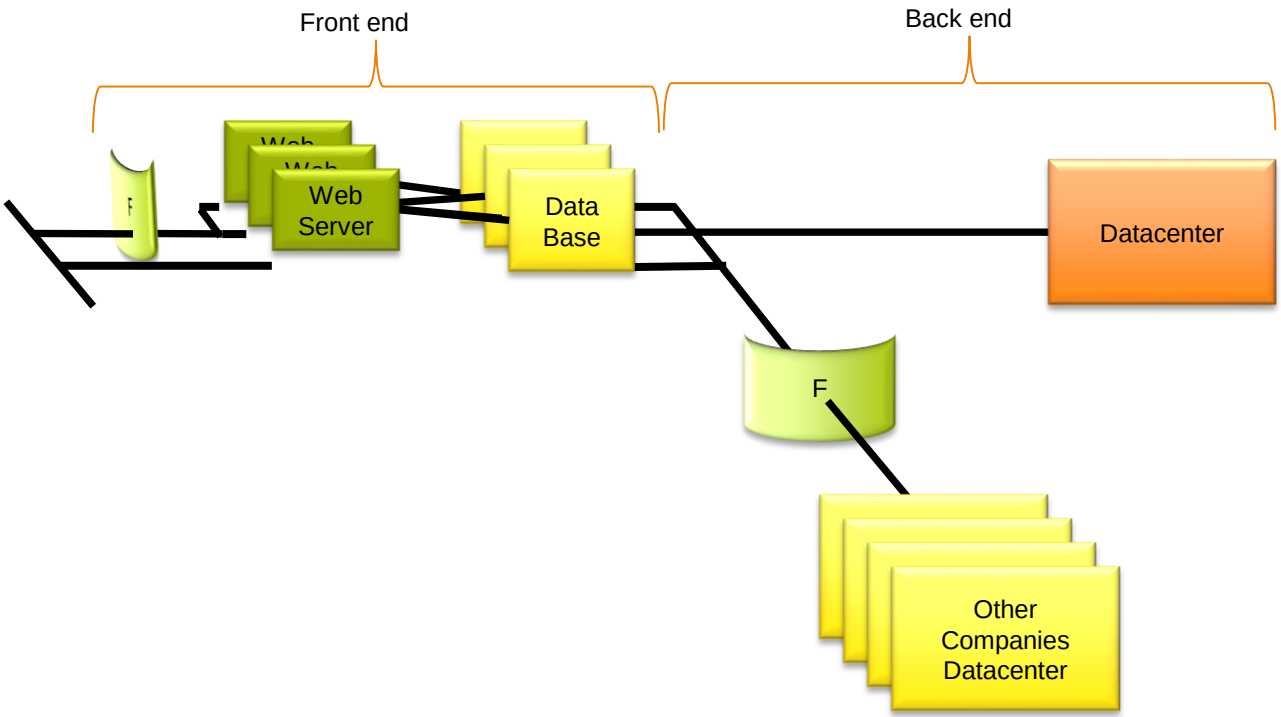


TAKEAWAY

SCALING AND DISTRIBUTION ALGORITHMS ARE KEY FOR IOT

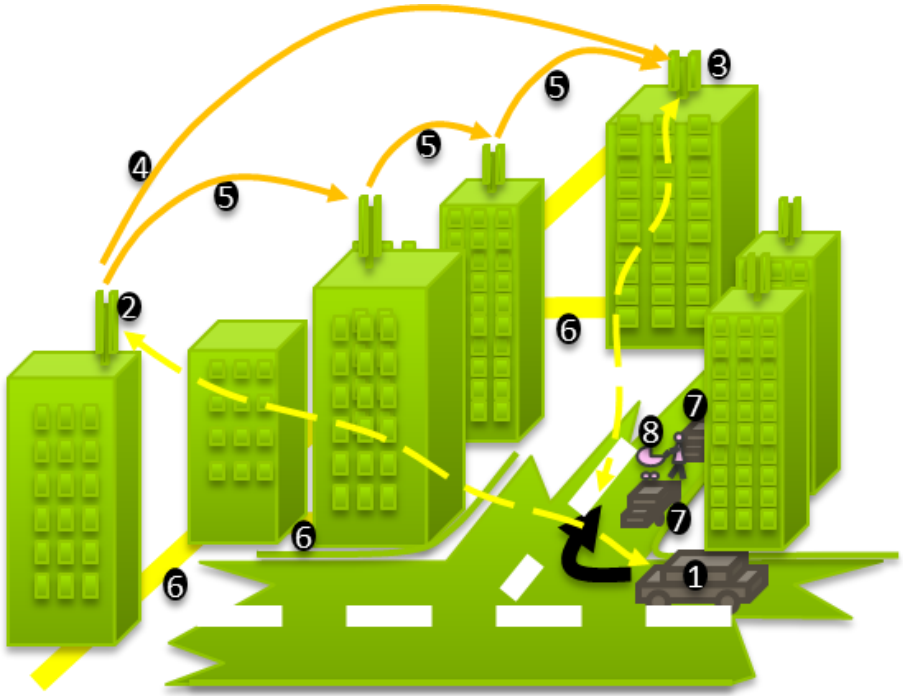
WHAT ARE THE APPLICATIONS?

FRONT-END SYSTEMS

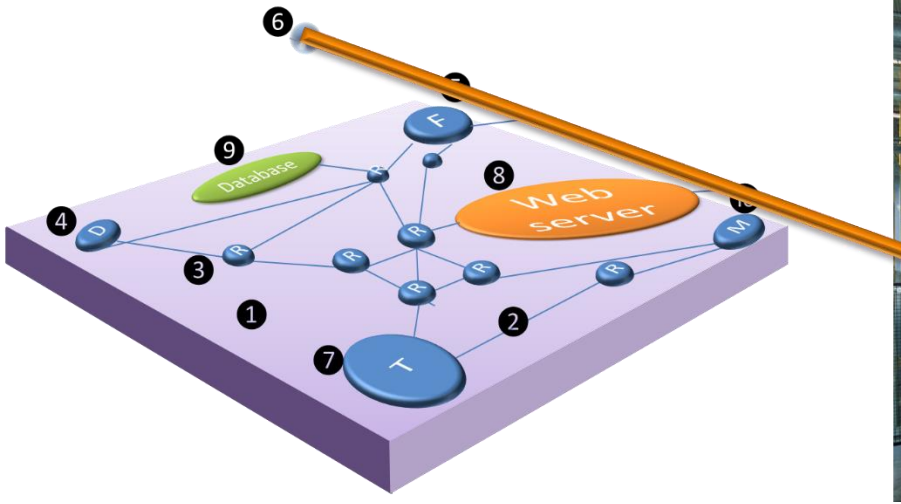


SDN & SMART MOBILITY

Master BsC 2016 TU Ilmenau (Germany), Adarsh Nayak



(SERVICES) THAT CONTROL MACHINES

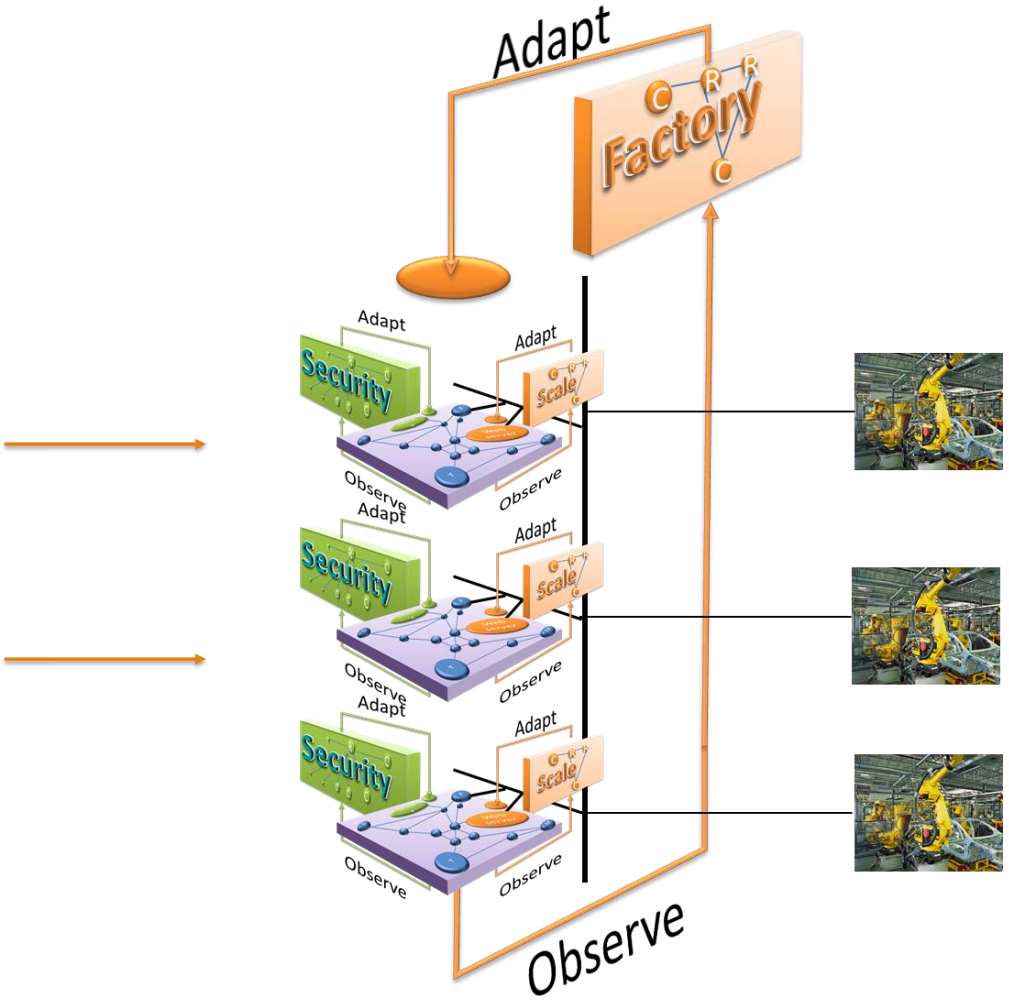


Factory robot

SMART FACTORY

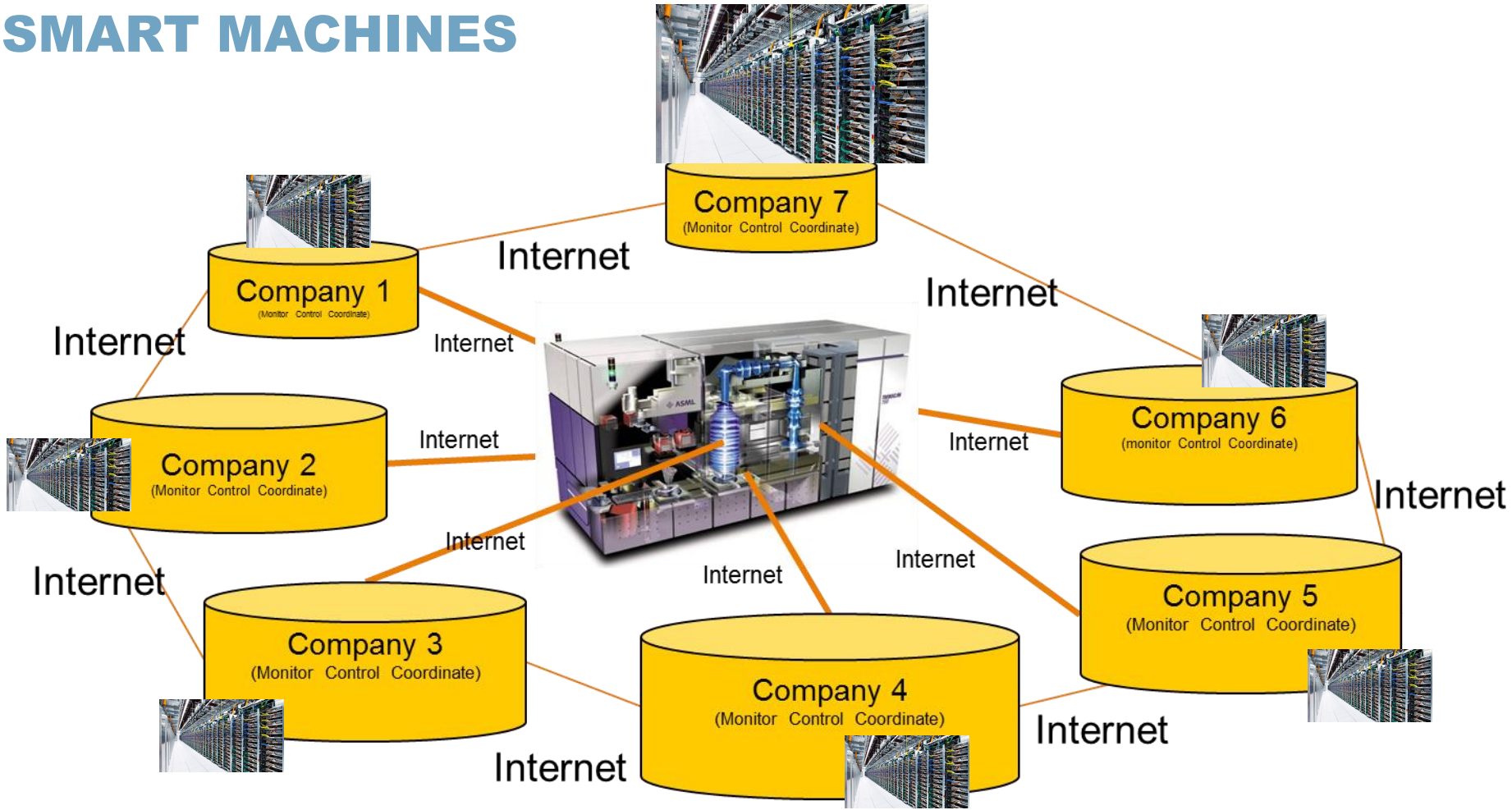
Computer brute force
+
human tweaking

Computer brute force
+
human tweaking



FUTURE WAFER STEPPERS -
10^6 WIRELESS SENSORS AND ACTUATORS

SMART MACHINES

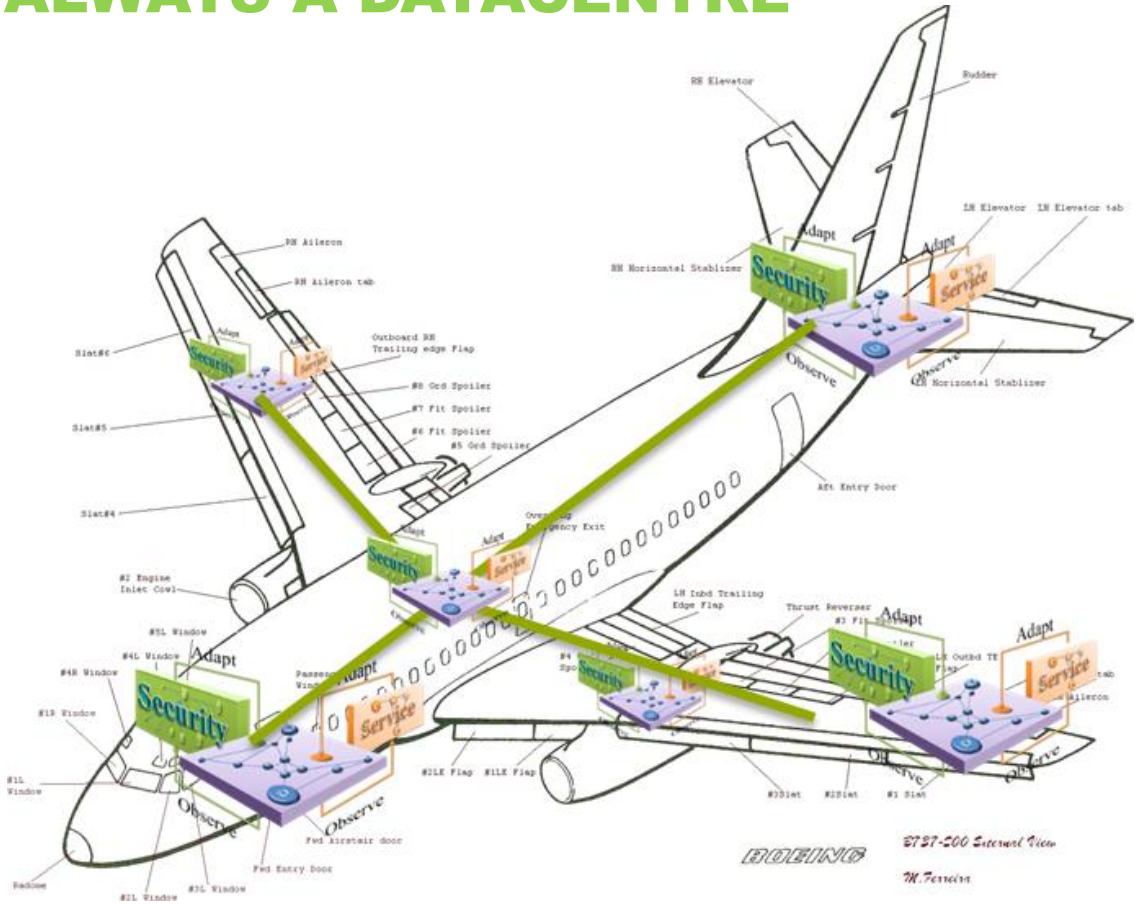


... COMPLEX MACHINES

THERE IS NOT ALWAYS A DATACENTRE

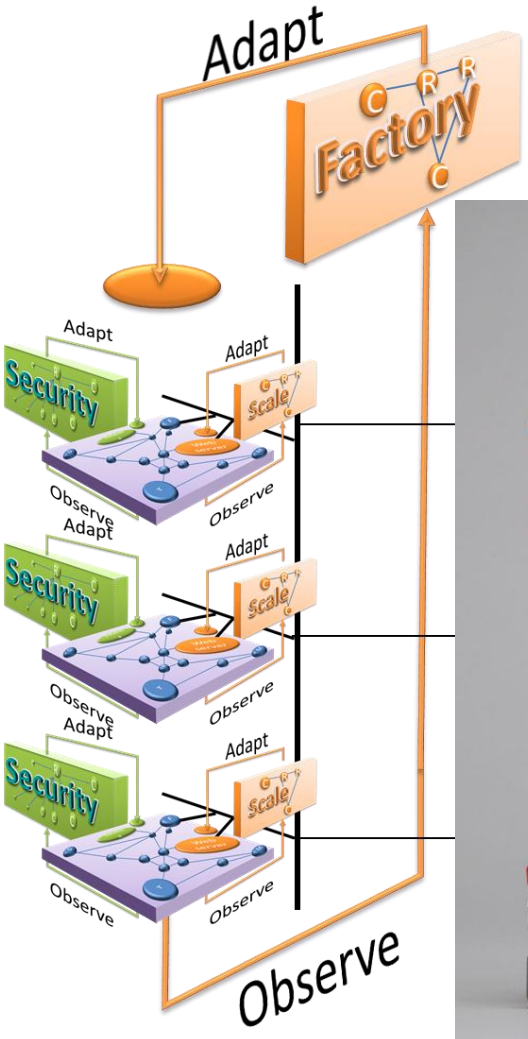
Software controlled ROBOTS

```
Program new_web_front_end(DC) {
Rent(3)_computers on datacenter(DC);
Start computer(1)(2)(3) on
                  datacenter(DC);
Run router(1)(2)(3) on
                  computer_(1)(2)(3) on
                  datacenter(DC);
Connect_router(1)(2)(3) on
                  datacenter(11) with
                  router(6)(7)(8) on
                  datacenter(DC);
Start services on computer (1)(2)(3);
}
```



MULTISCALE COOPERATION

MULTISCALE COOPERATION



TAKEAWAY

HIGH TECH FOR HIGH TECH APPS

NETWORKS ARE USED TO CONTROL THE REACH OF INTERWORKING APPLICATIONS

ADVANCED R&D THEMES

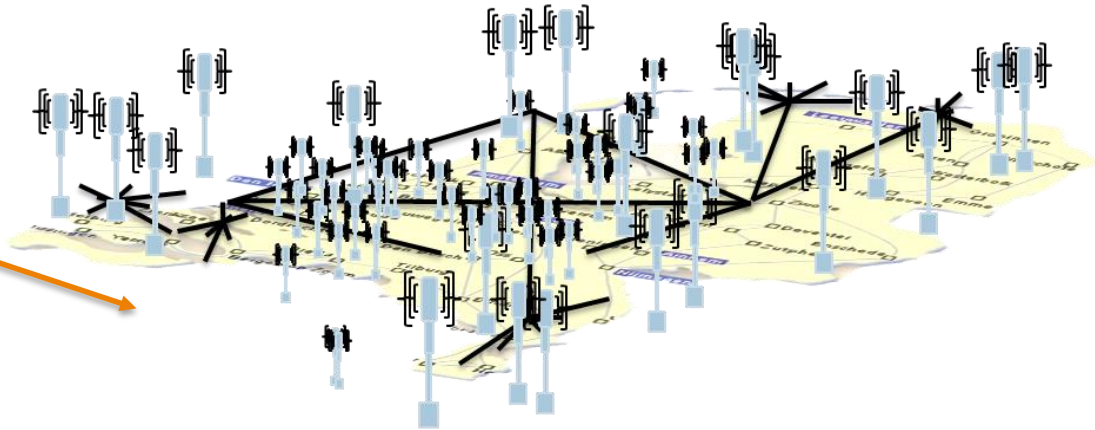
DYNAMIC NETWORKED ARCHITECTURES DNA

- Method for
  - Self Optimization
    - (Genetic programming)
  - Self Distribution
  - Self Organisation
  - Recursive Infrastructures

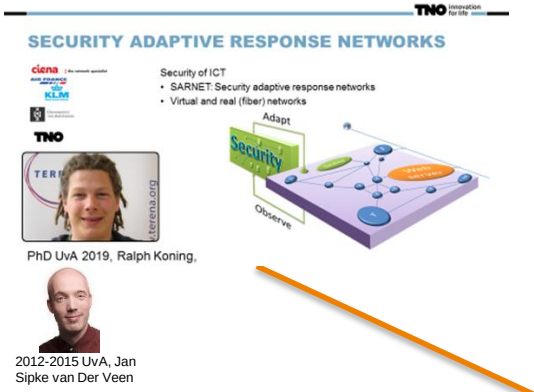
2012-2015 UvA, Jan Sipke van Der Veen

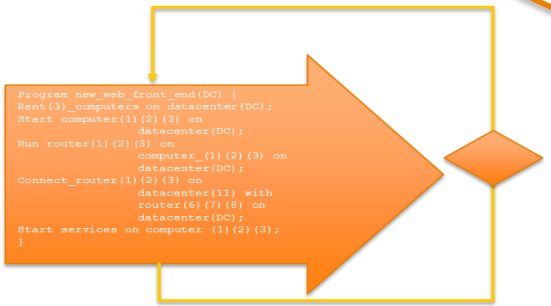
SELF DISTRIBUTING TELECOM AND SOFTWARE

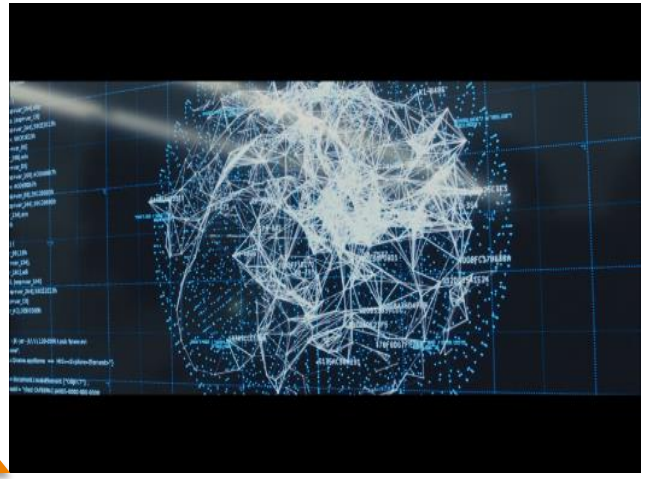
```
Program new_web_front_end(DC) {
Rent(3)_computers on datacenter(DC);
Start computer(1)(2)(3) on
                datacenter(DC);
Run router(1)(2)(3) on
                computer_(1)(2)(3) on
                datacenter(DC);
Connect_router(1)(2)(3) on
                datacenter(11) with
                router(6)(7)(8) on
                datacenter(DC);
Start services on computer (1)(2)(3);
}
```



NETWORKS THAT CHANGE BEFORE THEY ARE REVERSE ENGINEERED







THE SDI CAN BE SO DYNAMIC THAT THE PROGRAM IS THE ONLY THING WE UNDERSTAND

```
Program new_web_front_end(DC) {
Rent(3)_computers on datacenter(DC);
Start computer(1)(2)(3) on
                datacenter(DC);
Run router(1)(2)(3) on
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                datacenter(DC);
Connect_router(1)(2)(3) on
                datacenter(11) with
                router(6)(7)(8) on
                datacenter(DC);
Start services on computer (1)(2)(3);
}
```
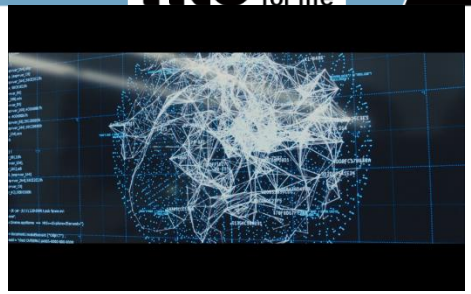
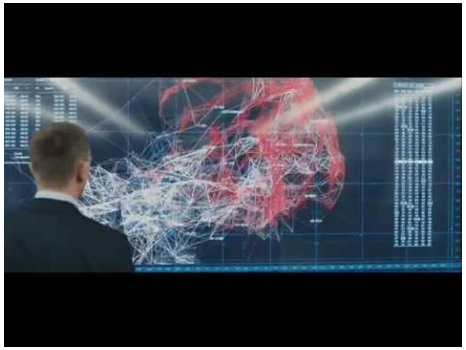

- PROGRAM → Dynamic Network Architecture
- DNA

How it currently works



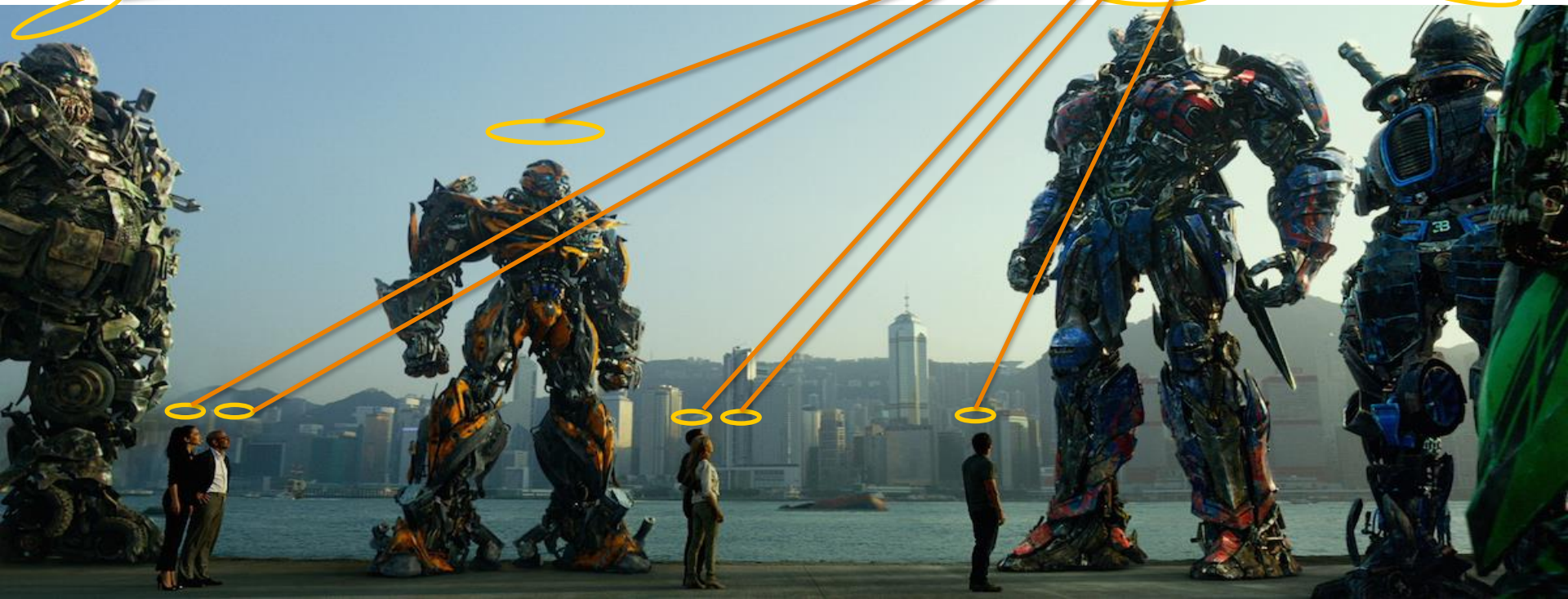
How it transforms



How it can be understood

007: “He hacked me”

MULTISCALE COOPERATION



FINAL TAKEAWAY

PROGRAMS BECOME THE ARCHITECTURE OF SDI

PROGRAMS BECOM THE DNA OF SDI
DYNAMIC NETWORKED APPLICATIONS

PARALLEL WITH BIOLOGY MIGHT NOT BE ACCIDENTAL

Q? A?