GreenClouds

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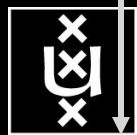
University of Amsterdam



Dutch Science Foundation (NWO)

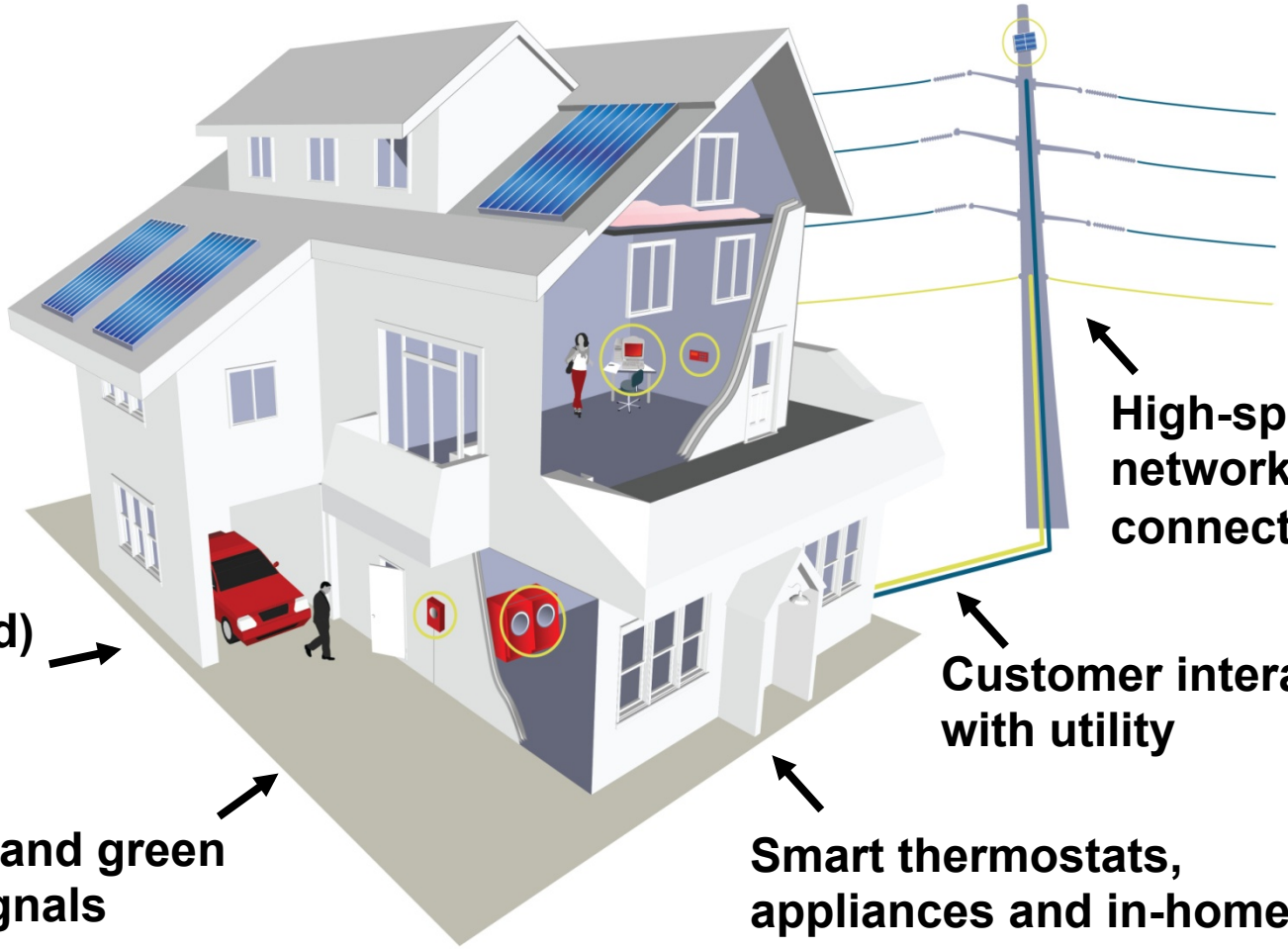
Smart Energy Systems call

- Spring 2010
- Awards in september 2010
- Start in 2011
- UvA & VU teamed up to submit GreenClouds
- Got award, PhD started last week
- http://www.nwo.nl/SES

Four focus areas

1. Smart ICT methods for energy saving, storage and generation in building environments
2. Smart control systems for flexible electricity networks (smart grids)
3. Energy reduction in processing and storing of information
4. Energy reduction in communication

Focus area 1



Smart House

Focus area 2: Today's electricity grids and efficiency

production

35-60%

Transmission & distribution

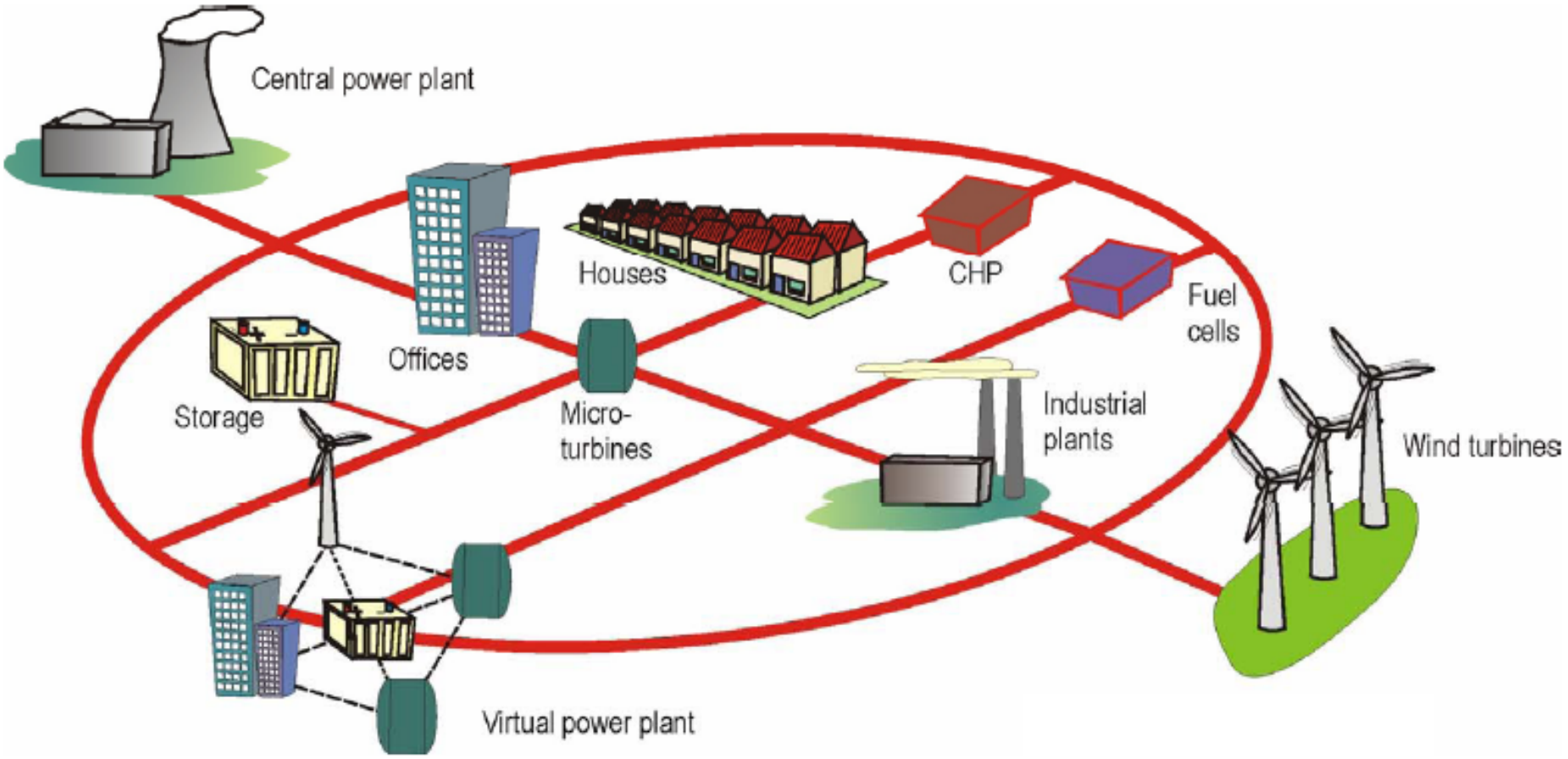
-7%

consumption

CHP

90%

The future: smart grids



Some ICT challenges ahead

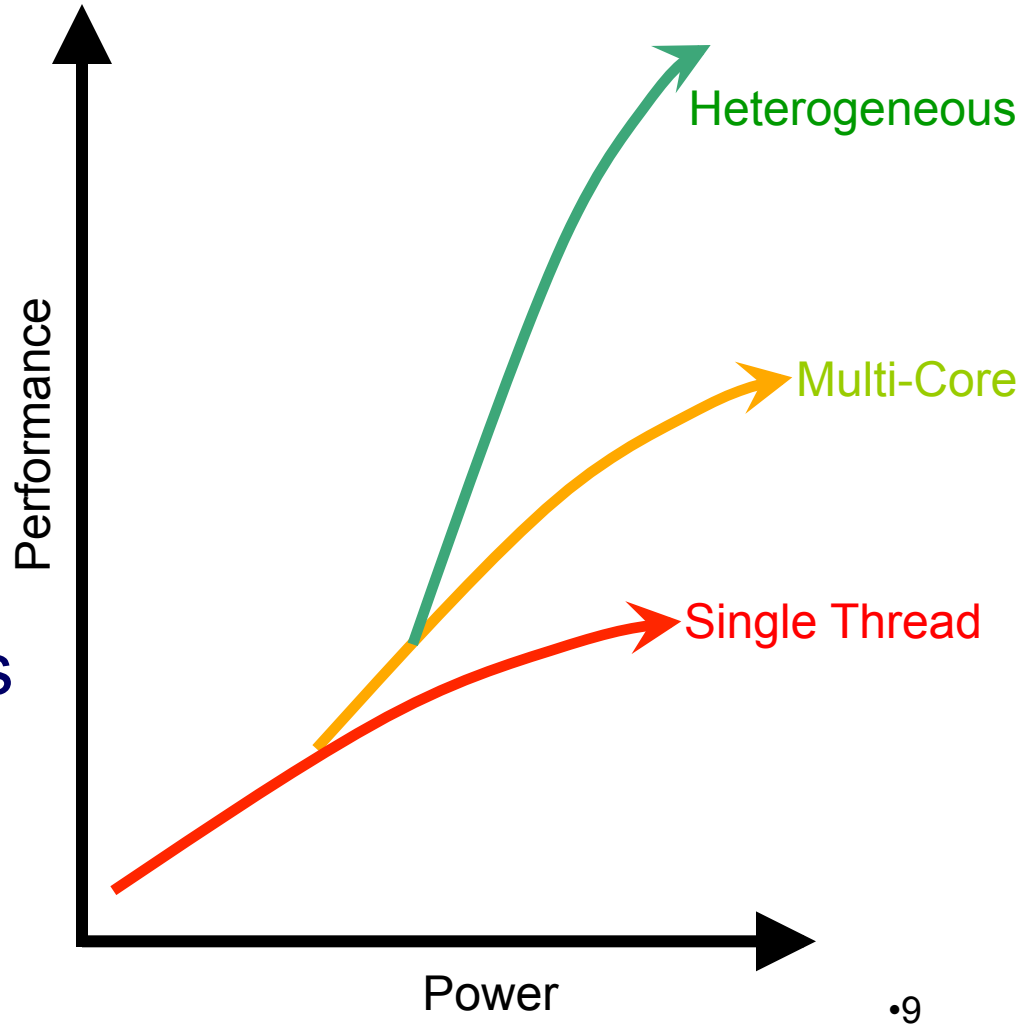
- Using ICT for efficiency implies efficient ICT
- Dependability of ICT
  - Smart grids are the life lines of our society
  - Should continue even when some parts fail
- Load balancing in the home / neighborhood
- Compensate for dynamics of generation (e.g. windmills)
- Scalability
  - Grid with thousands / millions of generators/consumers
  - Real-time control of thousands / millions of appliances
- Online optimization problems
  - Do I store energy locally or give it back to the grid?
  - Do I get energy from the battery or from the grid?

Focus area 3:
Energy reduction in processing

- Goal
  - Reduce energy consumption of ICT

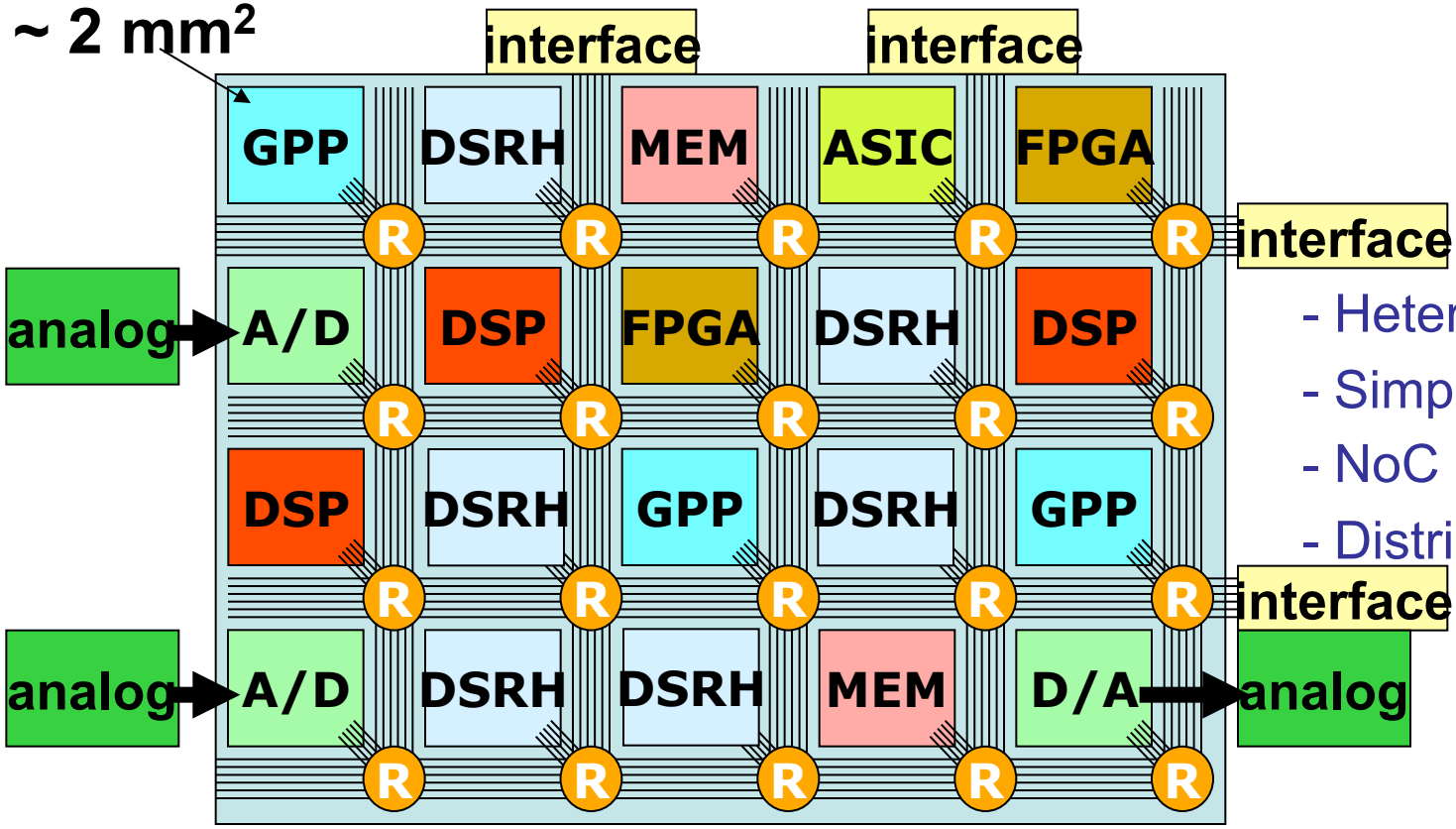
Microprocessor Trends

- Single Thread performance power limited
- Multi-core throughput performance extended
- Heterogeneous extends performance and efficiency



Slide from Peter Hofstee IBM

Future is in heterogeneous MPSoC Platforms



- Heterogeneous
- Simple tiles
- NoC
- Distributed Memory

Focus area 4
Energy reduction in communication

- Goal
  - Energy reduction in communication by using
    - Optical communication techniques
    - Wireless communication techniques
    - Intelligent networking techniques

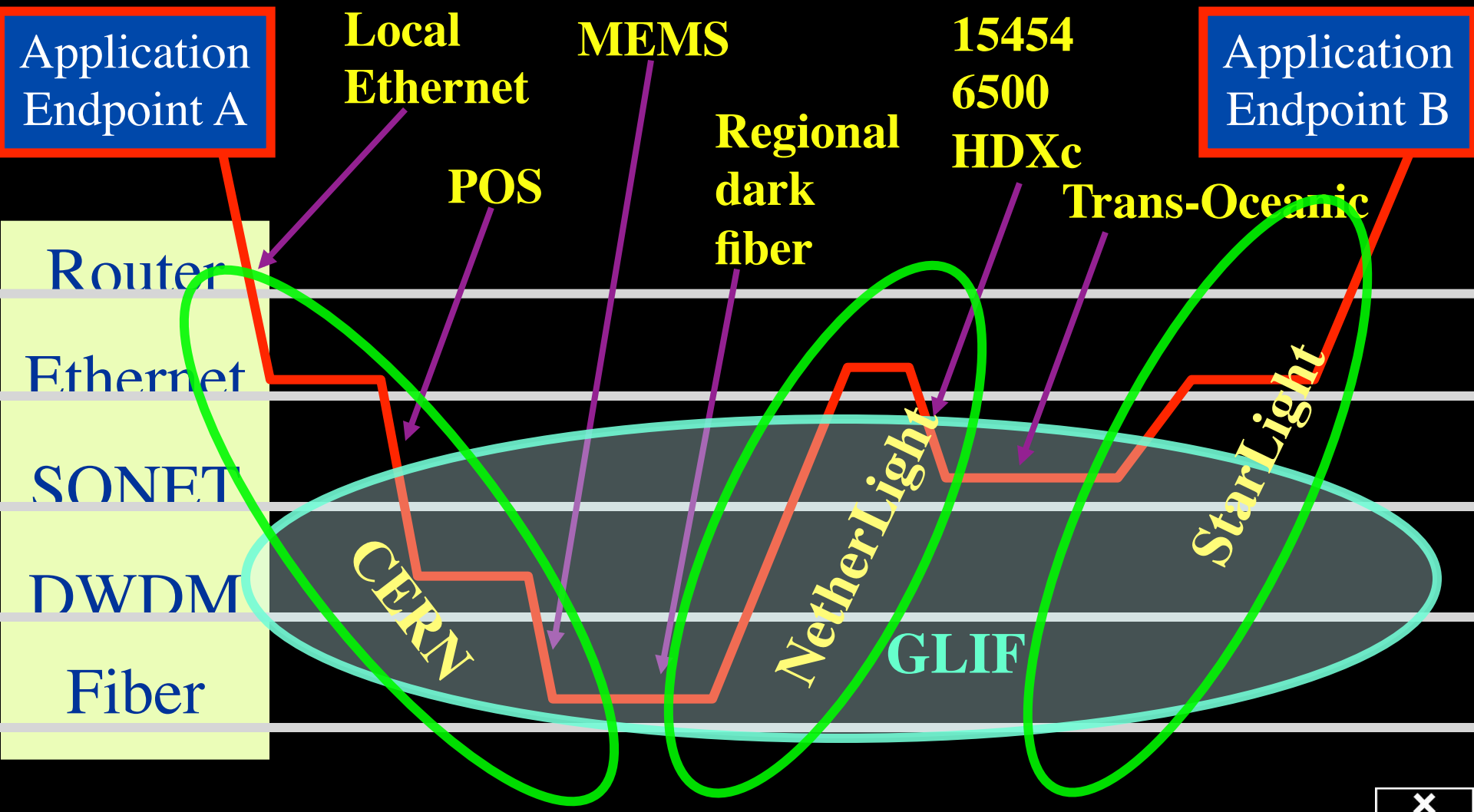
ICT challenges

- Optical fiber access networks
  - optical access by GPON consumes about 18x less energy per user than VDSL2
  - all-optical packet switching by avoiding power-hungry EO conversions
- Optimum combination of radio technologies with optical fiber technologies
- Low power cognitive radio transceivers
- Wideband transceivers and wake-up radios for small and adaptive cell sizes
- Low-power transceivers with strong spatial selectivity, MIMO and adaptive beamforming

Partners in GreenClouds

- Free University of Amsterdam
  - Henri Bal
- (really free) University of Amsterdam
  - Paola Grosso, Cees de Laat
- SARA
  - Axel Berg
- In context of:
  - ASCI
  - DAS4

How low can you go?



GreenClouds @ VU & UvA

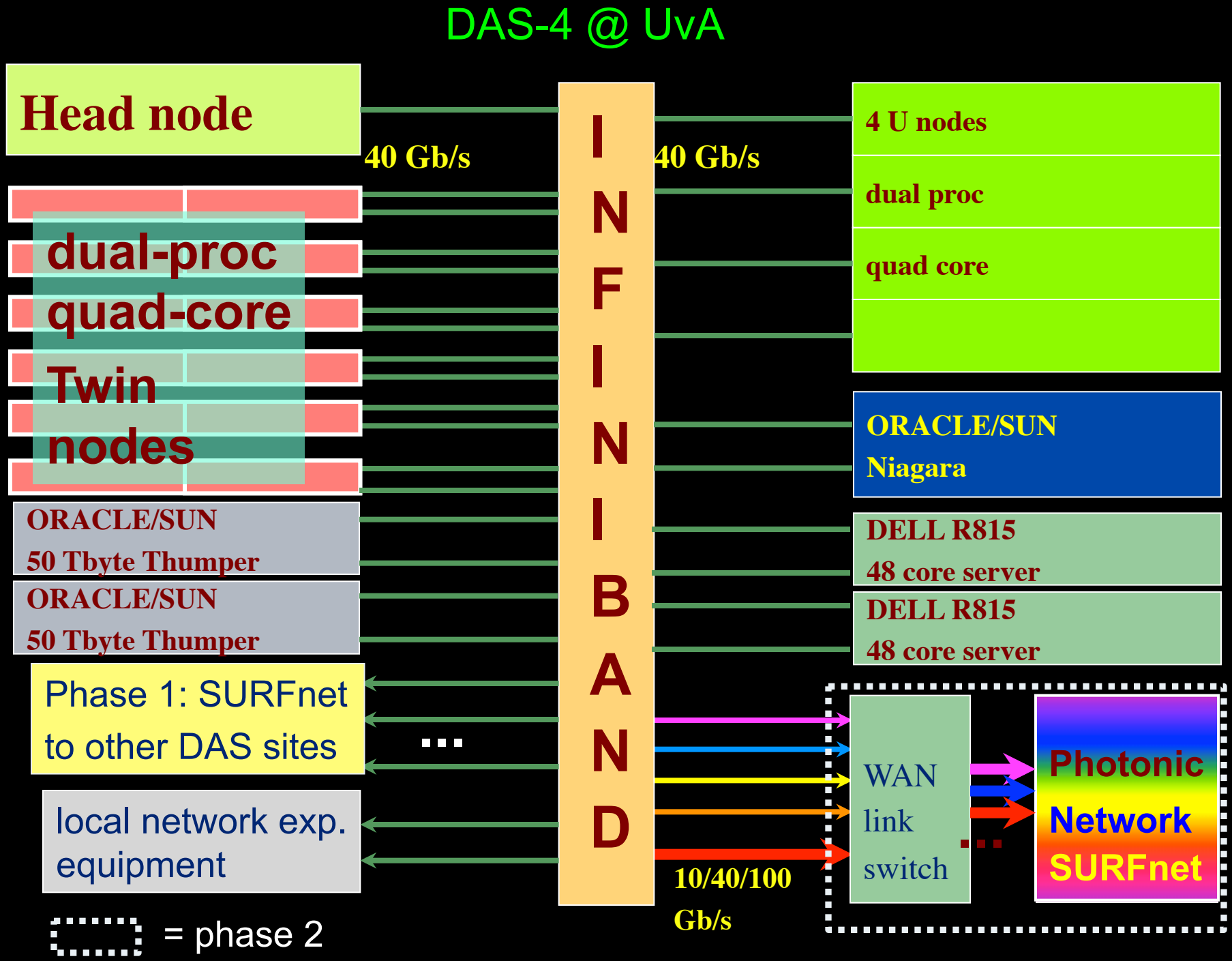
- The GreenClouds project studies how to reduce the energy footprint of modern High Performance Computing systems (like Clouds) that are distributed, elastically scalable, and contain a variety of hardware (accelerators and hybrid networks). The project takes a system-level approach and studies the problem of how to map high-performance applications onto such distributed systems, taking both performance and energy consumption into account.

- We will explore three ideas to reduce energy:
  1. Exploit the diversity of computing architectures (e.g. GPUs, multicores) to run computations on those architectures that perform them in the most energy-efficient way;
  2. Dynamically adapt the number of resources to the application needs accounting for computational and energy efficiency;
  3. Use optical and photonic networks to transport data and computations in a more energy-efficient way.

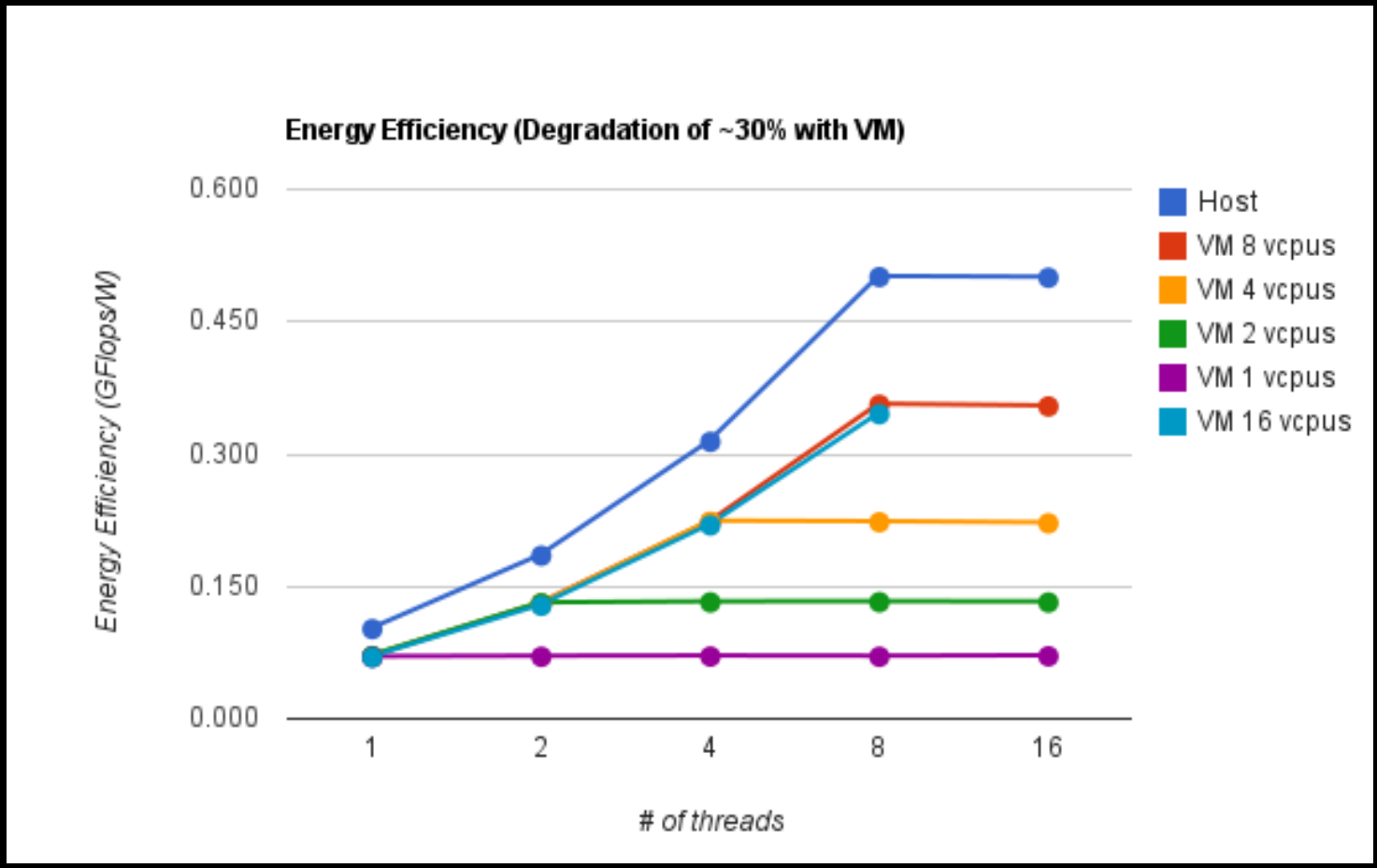
GreenClouds @ VU & UvA

- GreenClouds Knowledge Base System (GKBS) based on semantic web technology (NDL – alike)
  - detailed information on the energy characteristics of various applications (previous execution runs
  - Information on different parts of the distributed system, including the network.
- Determine classes of applications that can reduce their energy consumption using accelerators
- study energy reductions through dynamic adaptation of computing and networking resources.

The project will make extensive use of the DAS-4 infrastructure, which is a wide-area testbed for computer scientists, to be equipped with many types of accelerators, a photonic network, and energy sensors.


DAS-4 @ UvA
Head node
40 Gb/s
dual-proc
quad-core
Twin
nodes
ORACLE/SUN
50 Tbyte Thumper
ORACLE/SUN
50 Tbyte Thumper
Phase 1: SURFnet
to other DAS sites
local network exp.
equipment
= phase 2
INFINIBAND
40 Gb/s
4 U nodes
dual proc
quad core
ORACLE/SUN
Niagara
DELL R815
48 core server
DELL R815
48 core server
10/40/100
Gb/s
WAN
link
switch
Photonic
Network
SURFnet

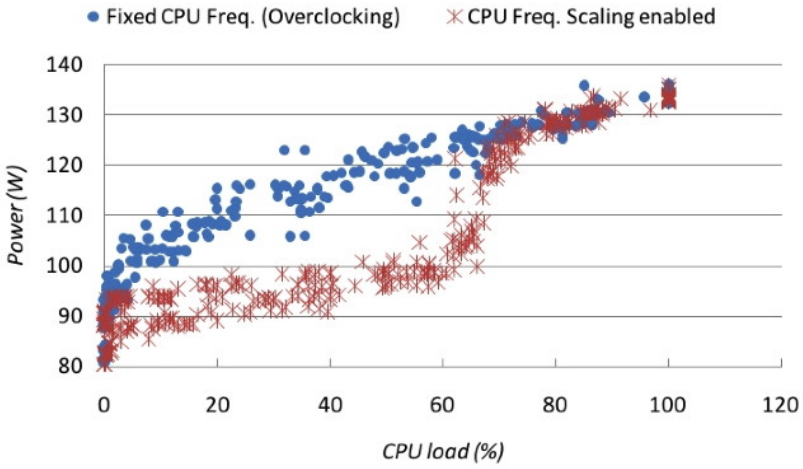
VM or host



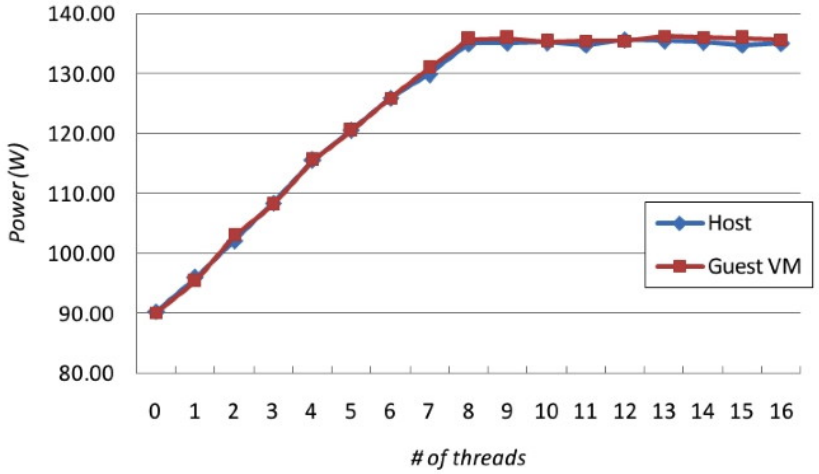
Each benchmark is run with the same amount of memory.

The degradation in energy efficiency of VMs is around 30% compared with the host.

CPU



Gradual increase of CPU load on all available cores

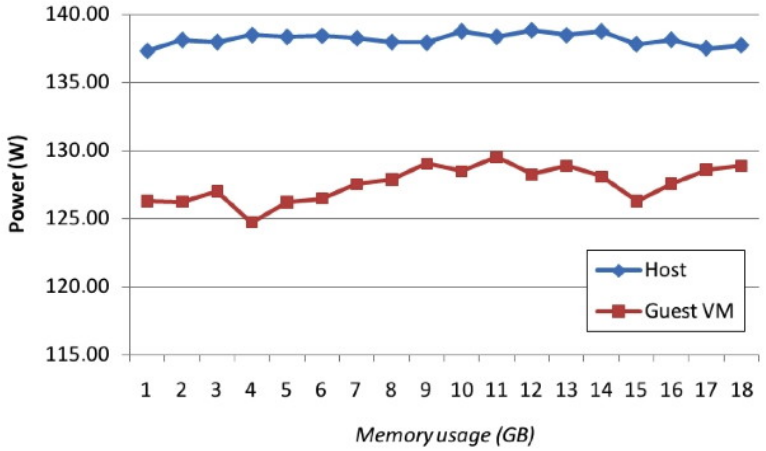


Gradual increase of number of cores, where each core is at its maximum usage

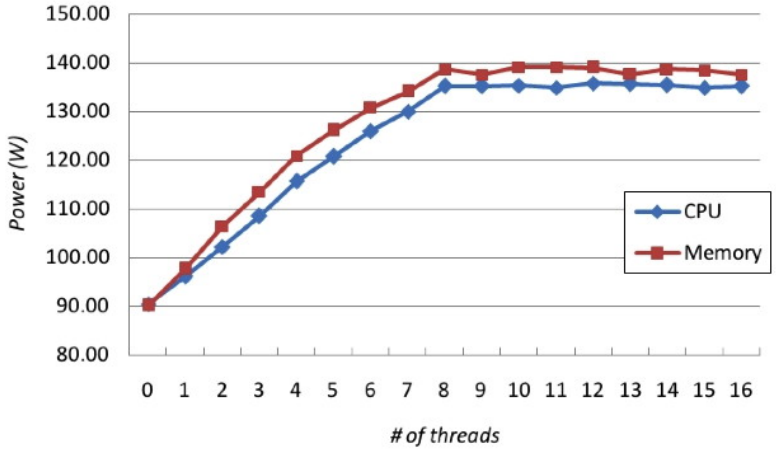
Observations

- Power usage is linear to the CPU load.
- No significant differences in power usage of a VM and its host.

Memory



Varying memory usage



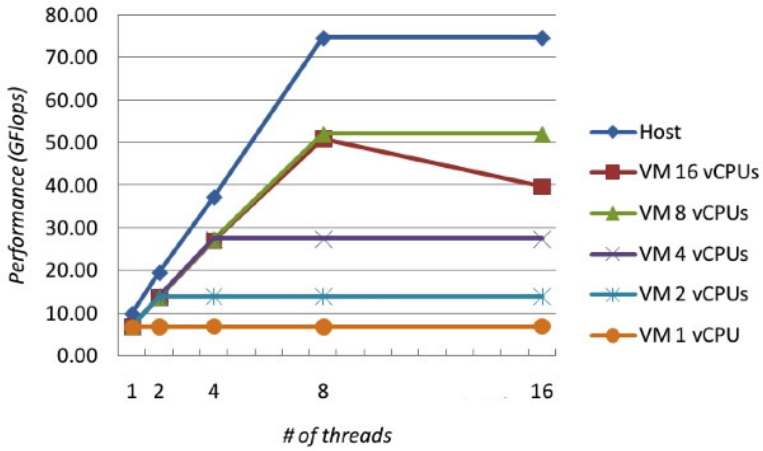
Memory and CPU stress tests

Observations

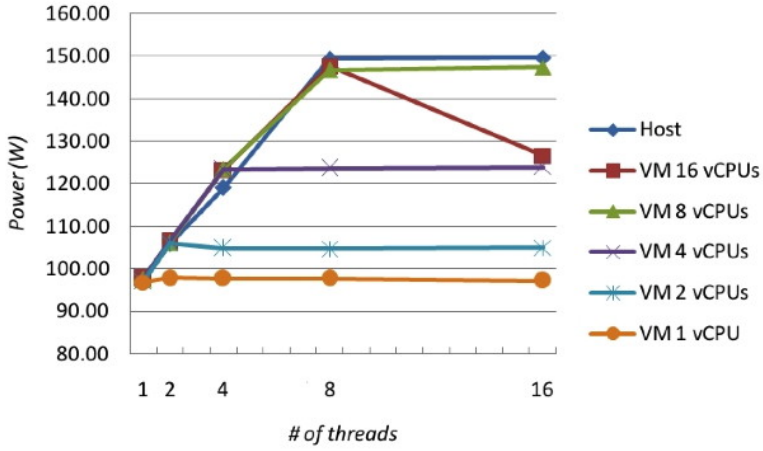
- Nearly constant power usage of memory
- Variation is less than 10% of total power usage

Overall benchmarks

Floating-point operation (Linpack) test



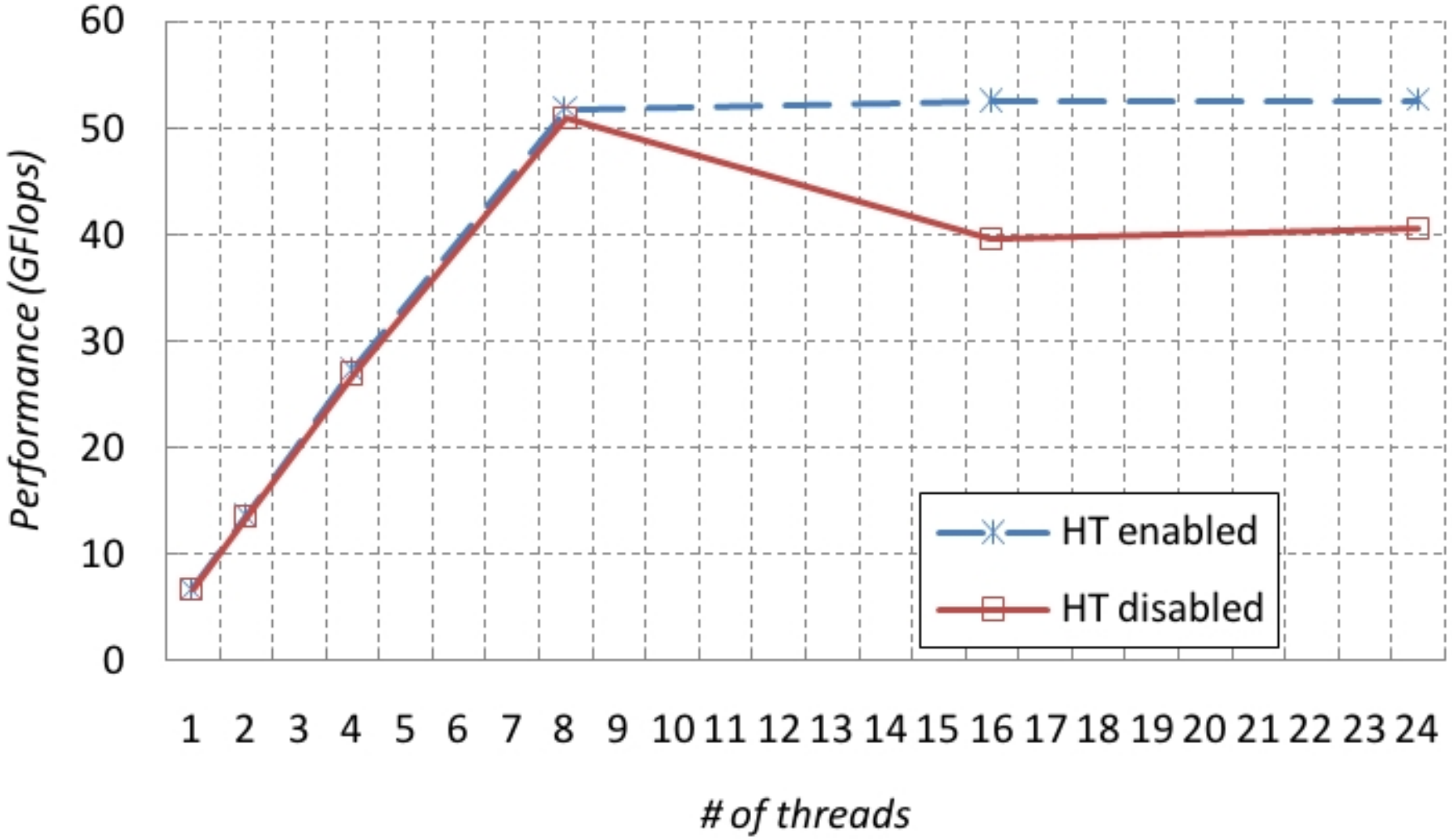
Performance



Power usage

Observations

- Performance $\propto$ CPU load (# of threads).
- Power usage is nearly linear to CPU load.
- Abnormal result for over-committed VM (i.e. with 16 vCPUs).

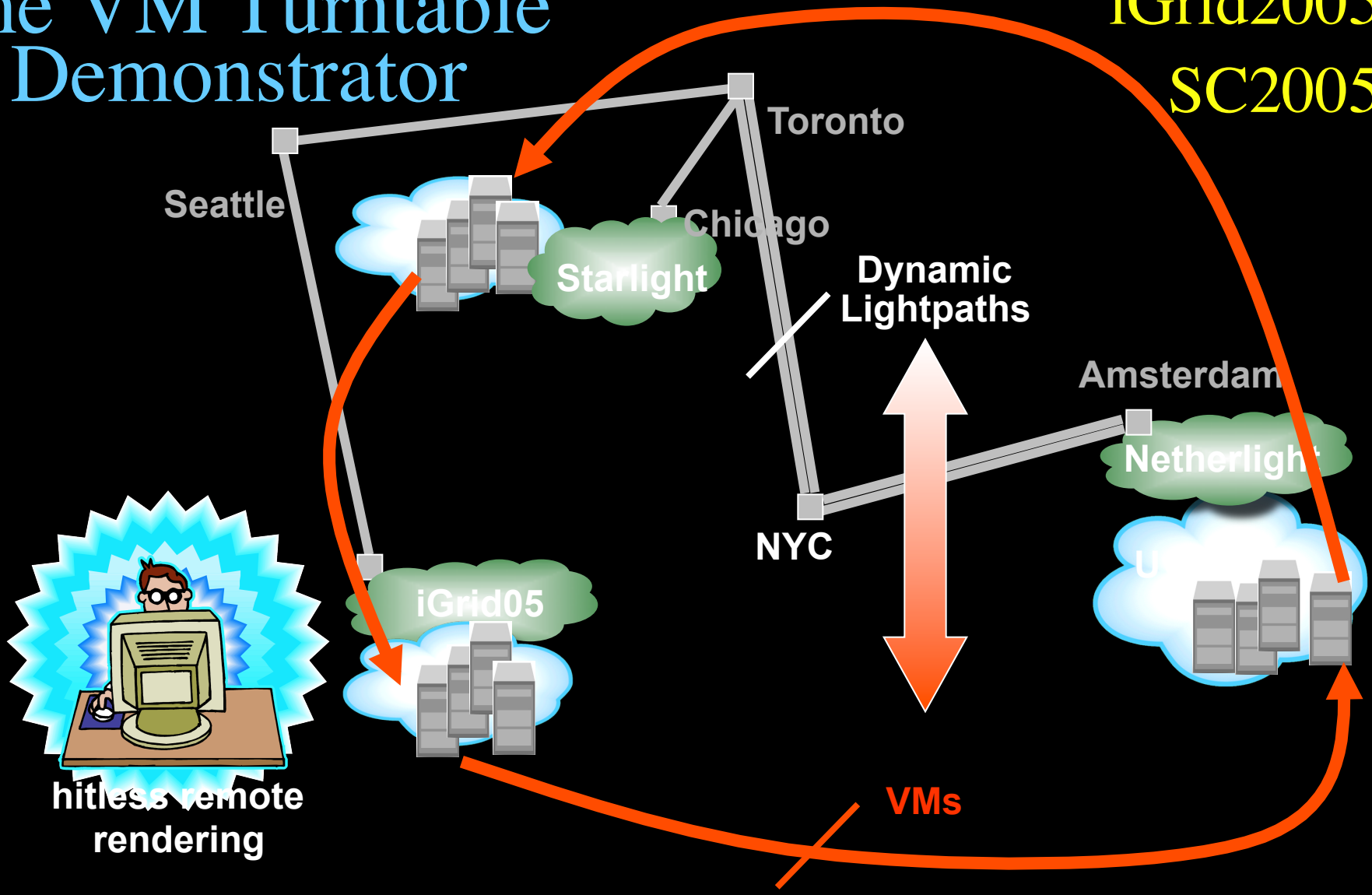

60
50
40
30
20
10
0
Performance (GFlops)
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
# of threads
HT enabled
HT disabled

Semantic web approach in GreenClouds

- Distributed info system describing current and historical load on infrastructure including parameters of jobs running
- Describe contextual parameters (energy sources, etc.)
- Dynamically optimize and migrate if context changes

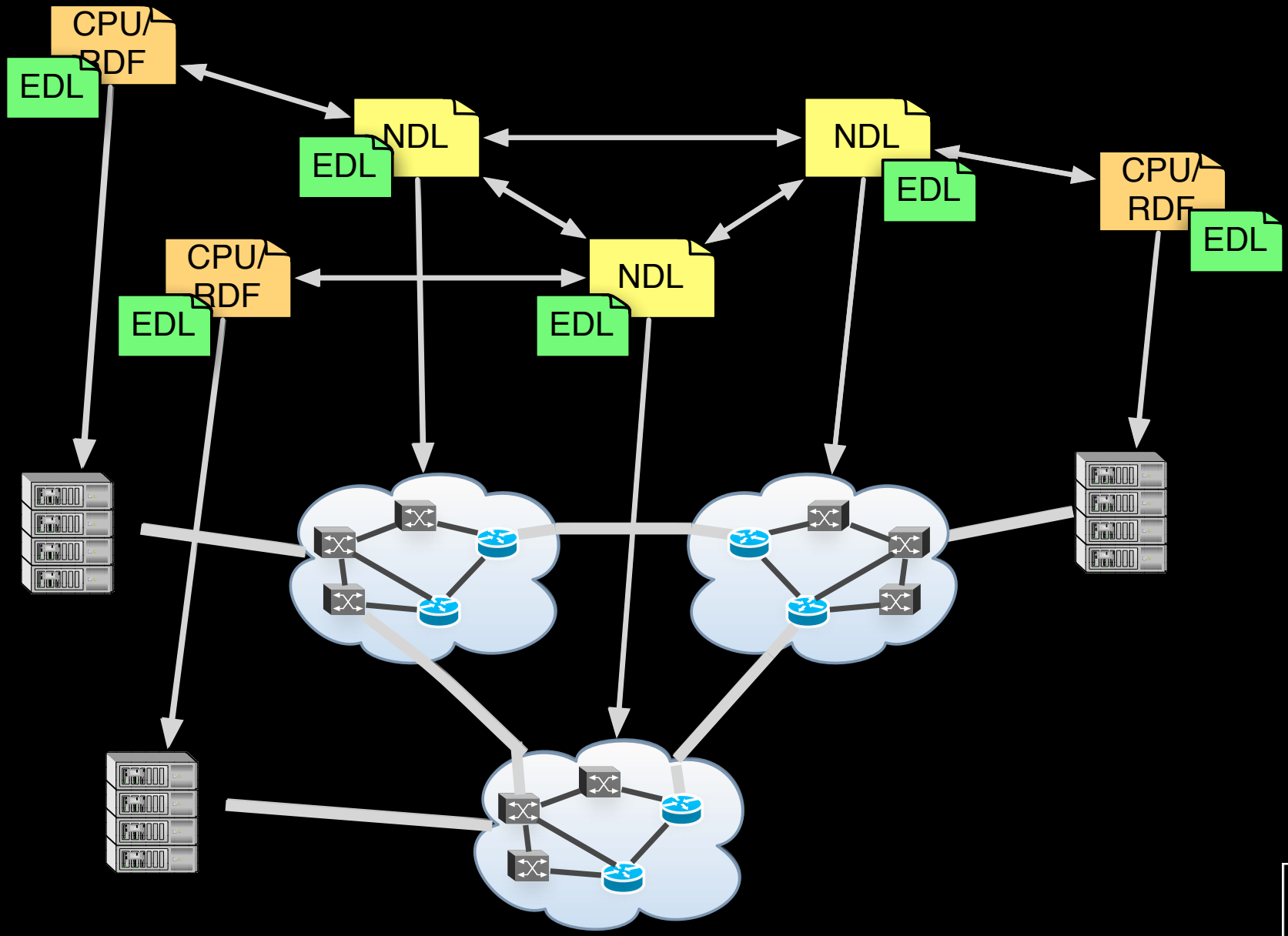
The VM Turntable Demonstrator

iGrid2005
SC2005

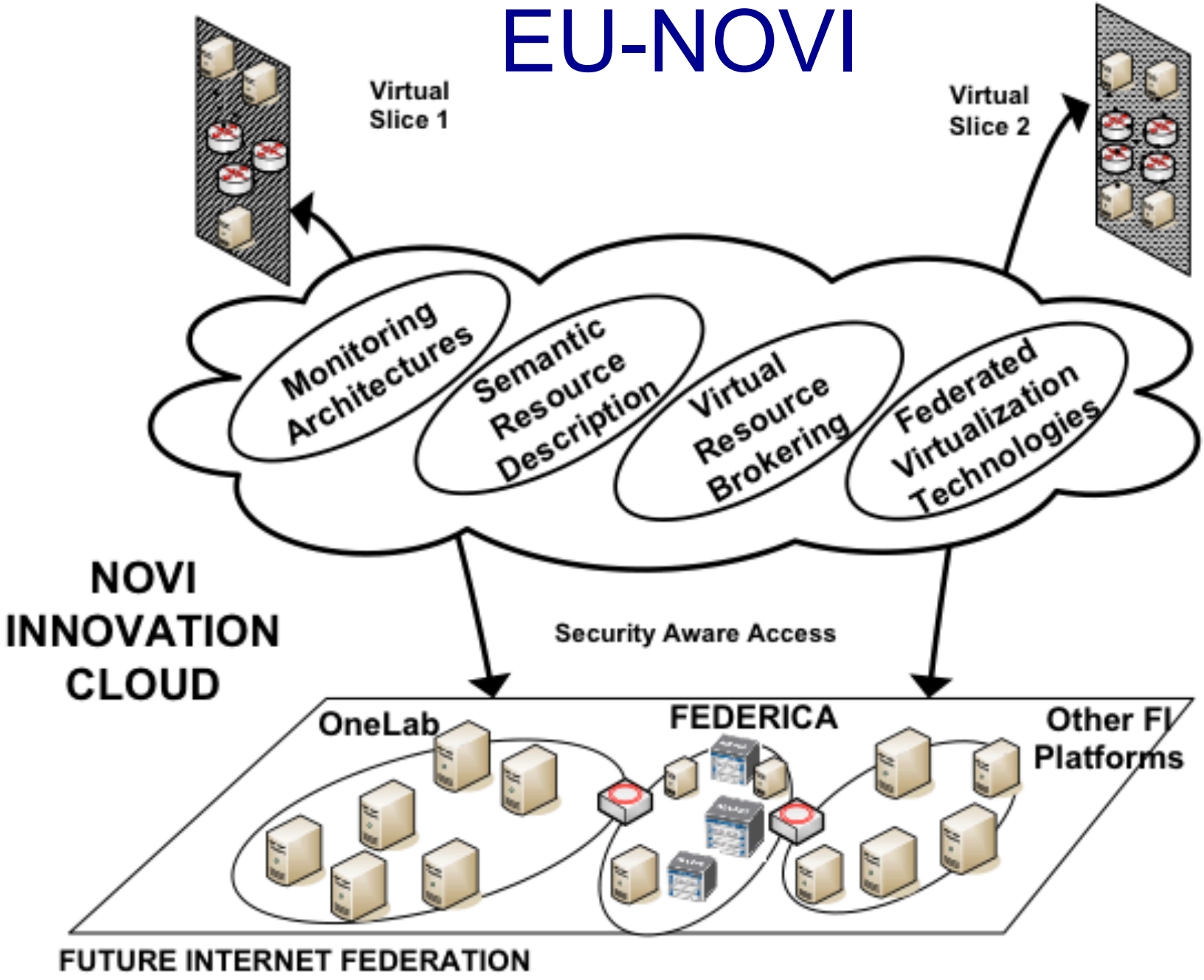


The VMs that are live-migrated run an iterative search-refine-search workflow against data stored in different databases at the various locations. A user in San Diego gets hitless rendering of search progress as VMs spin around

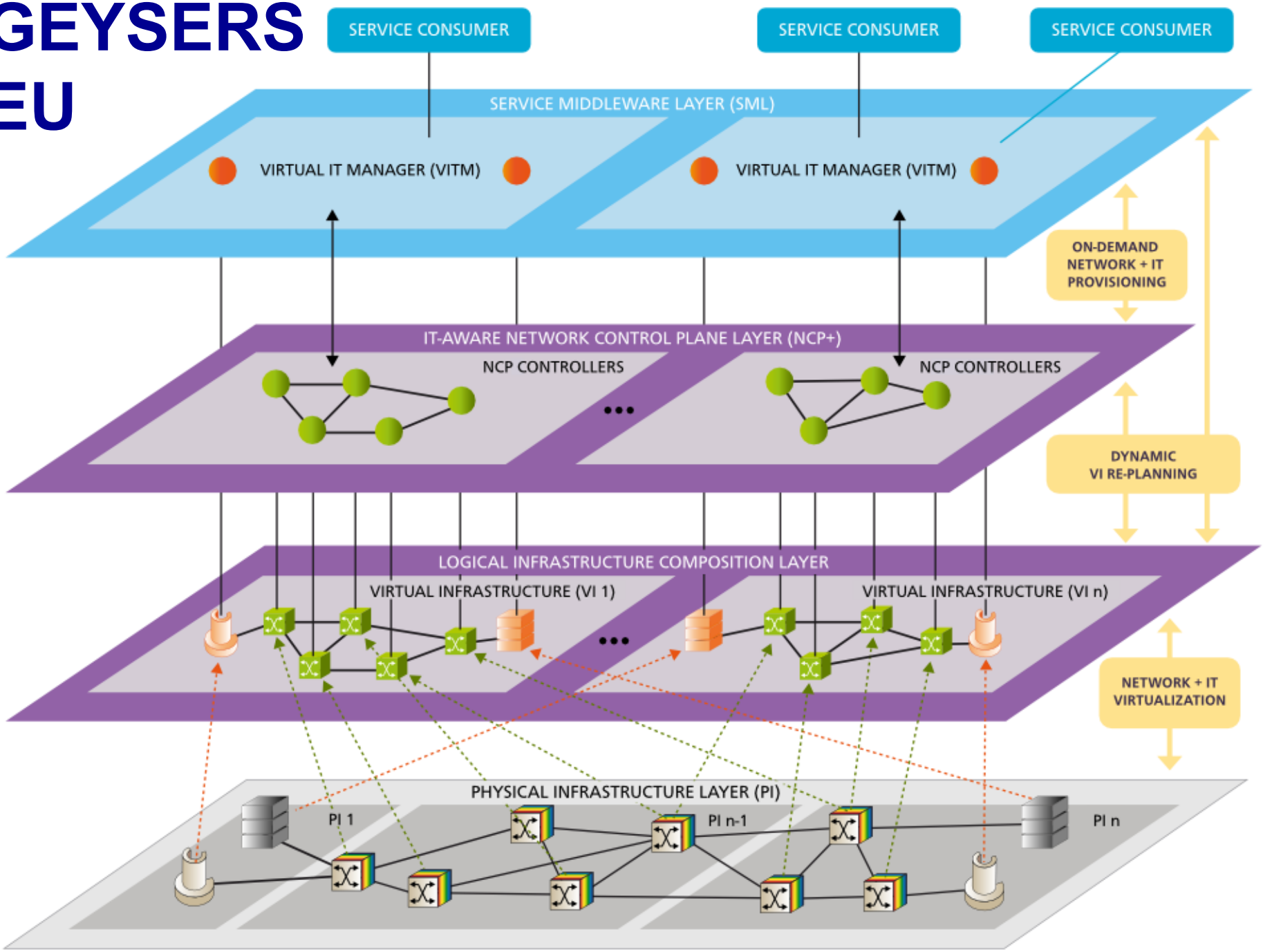
Semantic Framework



EU-NOVI


Virtual Slice 1
Virtual Slice 2
Monitoring Architectures
Semantic Resource Description
Virtual Resource Brokering
Federated Virtualization Technologies
NOVI INNOVATION CLOUD
Security Aware Access
OneLab
FEDERICA
Other FI Platforms
FUTURE INTERNET FEDERATION

GEYSERS EU


SERVICE CONSUMER
SERVICE CONSUMER
SERVICE CONSUMER
SERVICE MIDDLEWARE LAYER (SML)
VIRTUAL IT MANAGER (VITM)
VIRTUAL IT MANAGER (VITM)
ON-DEMAND NETWORK + IT PROVISIONING
IT-AWARE NETWORK CONTROL PLANE LAYER (NCP+)
NCP CONTROLLERS
NCP CONTROLLERS
DYNAMIC VI RE-PLANNING
LOGICAL INFRASTRUCTURE COMPOSITION LAYER
VIRTUAL INFRASTRUCTURE (VI 1)
VIRTUAL INFRASTRUCTURE (VI n)
NETWORK + IT VIRTUALIZATION
PHYSICAL INFRASTRUCTURE LAYER (PI)
PI 1
PI n-1
PI n

ECO-Scheduling

Hybrid computing

Routers ⇐ ⇒ Supercomputers

Ethernet switches ⇐ ⇒ Grid & Cloud

Photonic transport ⇐ ⇒ GPU's

What matters:

Energy consumption/multiplication

Energy consumption/bit transported

Q&A

http://ext.delaat.net/smartgreen/index.html