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新世代インターネットへ向けた研究開発について

2008年7月9日
NECシステムプラットフォーム研究所
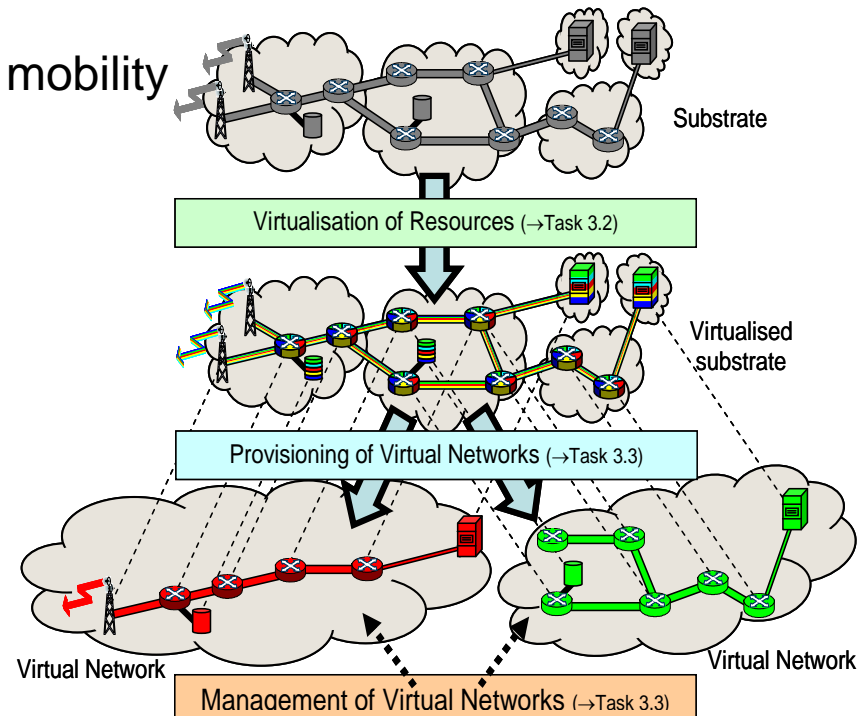## 岩田　淳

Outline

1. USA, EU and Japan research activity overview

2. USA's research activities toward new generation network

   - NSF NeTS-FIND
   - NSF GENI

3. Key elements of future network research

   - Expectations to GENI projects

4. NEC's research activities toward new generation network

   - Vision & basic architecture
   - Current research activities as a first step

5. Conclusion

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USA and EU research activity overview

- USA: NeTS-FIND/GENI
- EU: FP7/4WARD, TRILOGY
- Japan: New Generation Network (NwGN)
- Common target:
  - Virtualization / Programmable network for next generation internet
    - Computer & network integrated programmable network node
    - Optical dynamic circuit switch
    - Programmable radio & Dynamic mobility

PWN: Programmable Wireless Node
PEN: Programmable Edge Node
PEC: Programmable Edge Cluster
PCN: Programmable Core Node
GGW: GENI Gateway
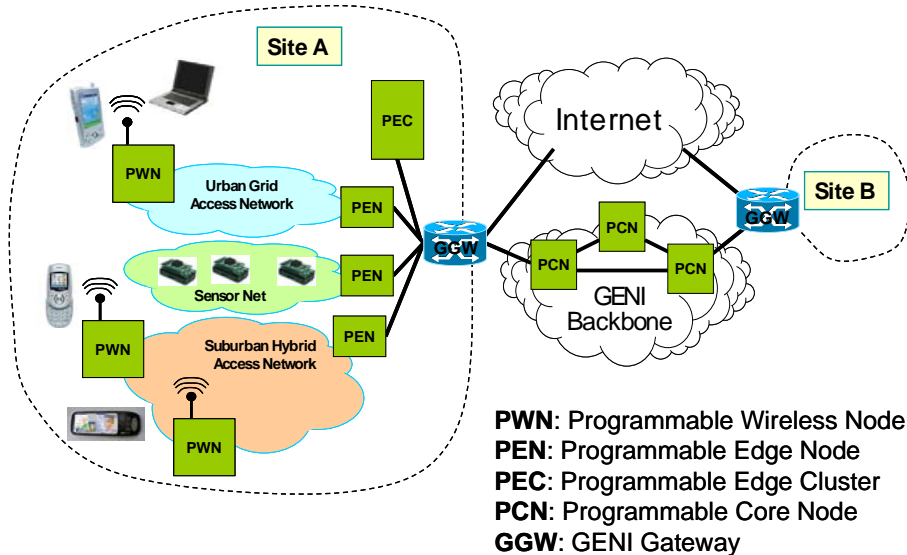
USA: NSF GENI Project

EU: FP7 4WARD Project

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USA's research activities toward next generation internet – NSF NeTS-FIND/GENI

- ## NSF Research Projects
  - NeTS (Networking Technology and Systems)
    - FIND (Future Internet Design)
      - http://www.nets-find.net/
      - 42 funded projects (Jan. 2008)
      - Research areas: Virtualization, New routing/forwarding scheme, New security, New management, New protocol stacks, …

- ## NSF Research Testbed and Trial Projects
  - GENI (Global Environment for Networking Innovations)
    - http://www.geni.net/
    - On going call for proposals (until Feb.2008)
    - Areas: anaysis and idea (~25 proposals), prototype (~20 proposals), Trial integration (~4 proposals)
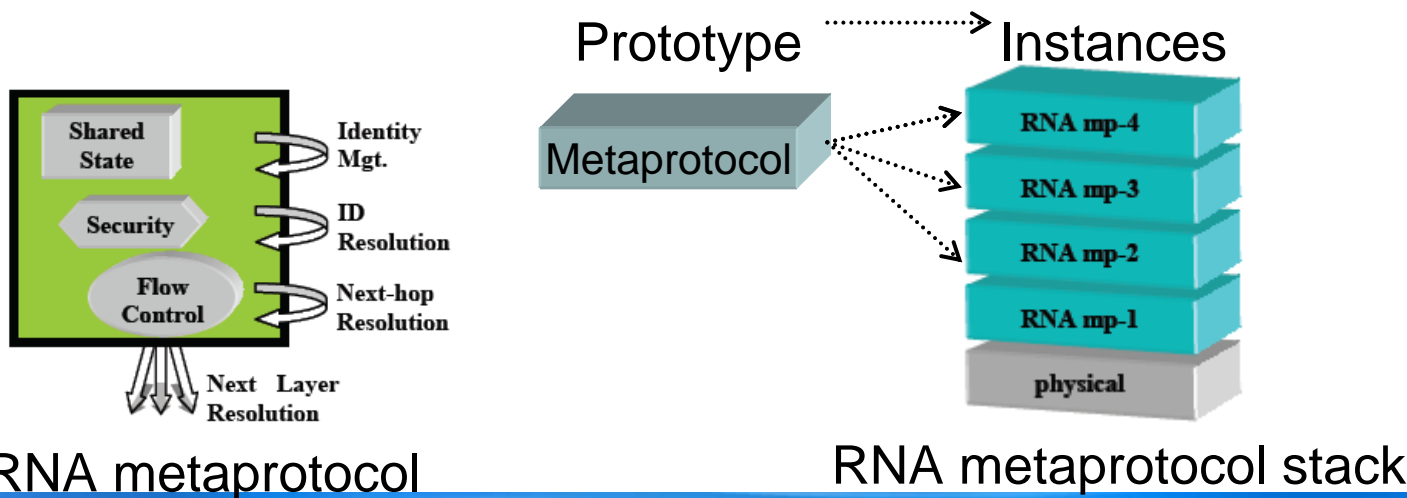
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NeTS-FIND (Future Internet Design) – Interesting trend #1-

- Proposal: Recursive Network Architecture (RNA)
  - Joe Touch @ ISI
  - Primary goal
    - Cleaner cross-layer interaction
    - Support dynamic service composition
  - Defines "MetaProtocol"
    - Single and tunable protocol for different layers
    - Reuse basic protocol operations to avoid re-implementations

➡️ Opportunity for flexible protocol configuration

Prototype ·········> Instances

Metaprotocol

Shared State	Identity Mgt.
Security	ID Resolution
Flow Control	Next-hop Resolution

Next Layer Resolution

RNA mp-4
RNA mp-3
RNA mp-2
RNA mp-1
physical

RNA metaprotocol

RNA metaprotocol stack

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NeTS-FIND (Future Internet Design) – Interesting trend #2–

- Proposal: Diversified Internet
  - Jonathan Turner @ Washington-U
  - Goal: Provides Metanet using MeraRouter and MetaLink
  - Substrate Domain Controller (SDC) and Metanet Controller (MC) controls usage of physical resources
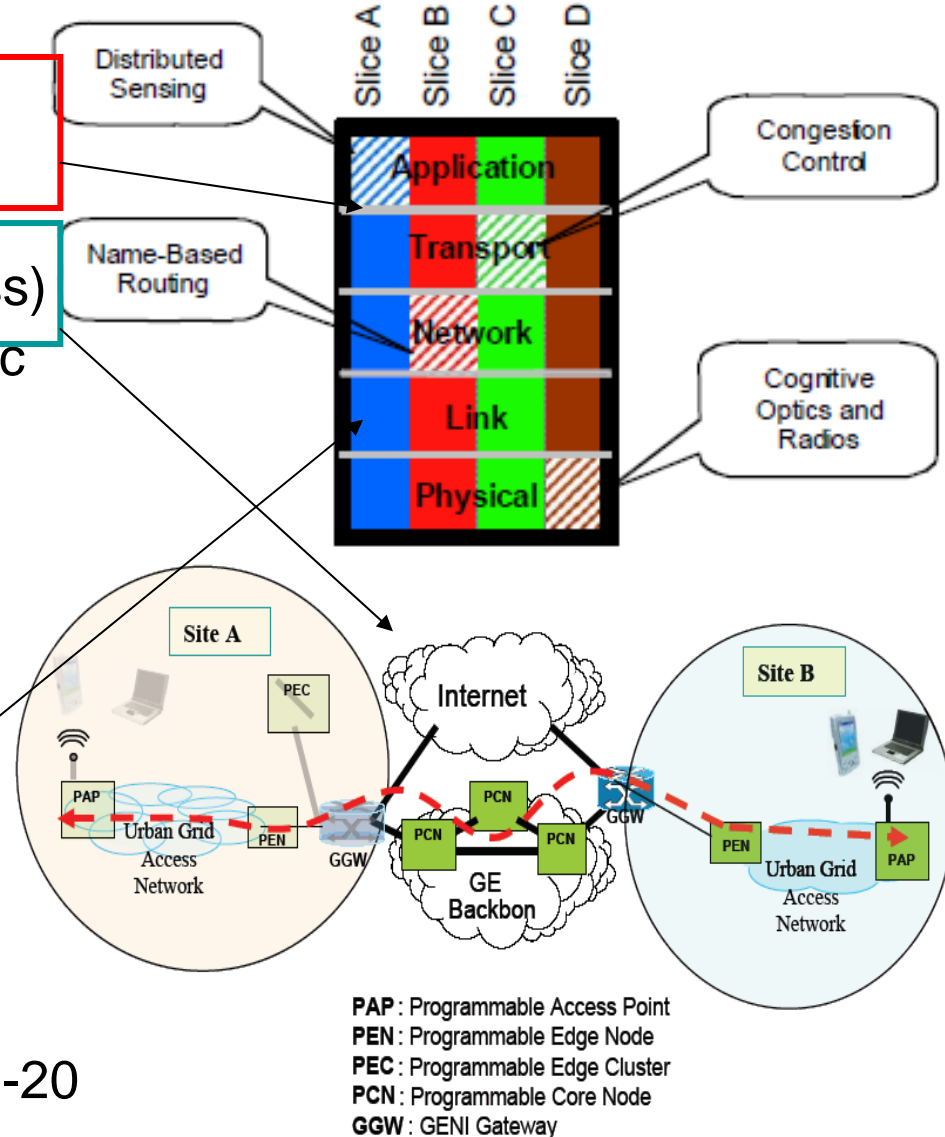
➡️ Opportunity for network virtualization / meta-network

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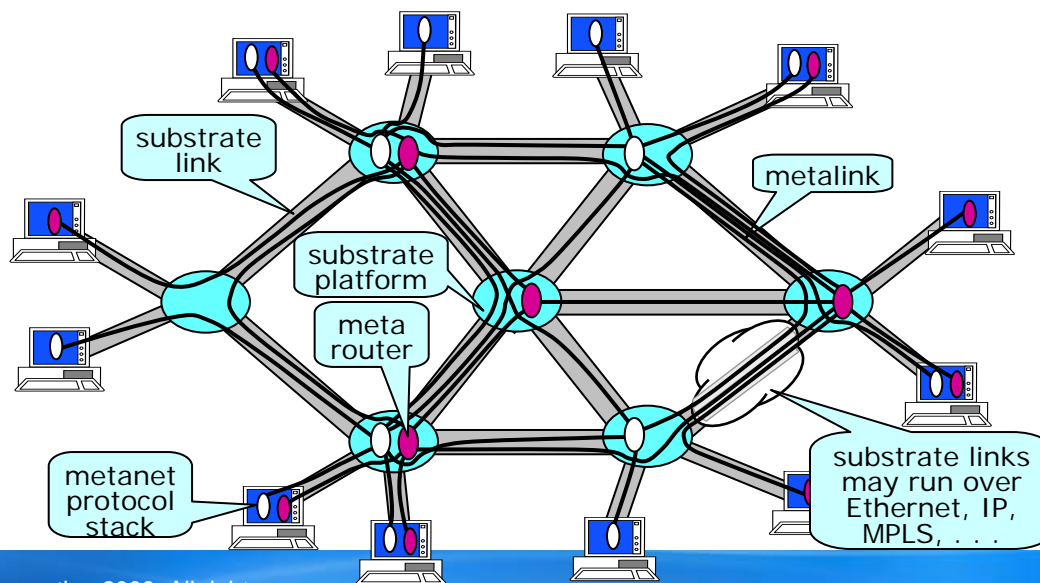
NSF GENI (Global Environment for Networking Innovations)

- Research goal:
  - Generality (programmable component)
  - Diversity & Extensibility (Heterogenous wired and wireless)
  - Fidelity (Coexistence of real traffic and experimental traffic)
  - Observability (Quantitative evaluation)
  - Ease of Use
  - Sliceability (Shared facility for multiple experiments)
  - Controlled Isolation (Prohibit interference)
  - Opt-in (service trials)
  - Security
  - Federation and Sustainability (15-20 year life-time)

PAP : Programmable Access Point
PEN : Programmable Edge Node
PEC : Programmable Edge Cluster
PCN : Programmable Core Node
GGW : GENI Gateway

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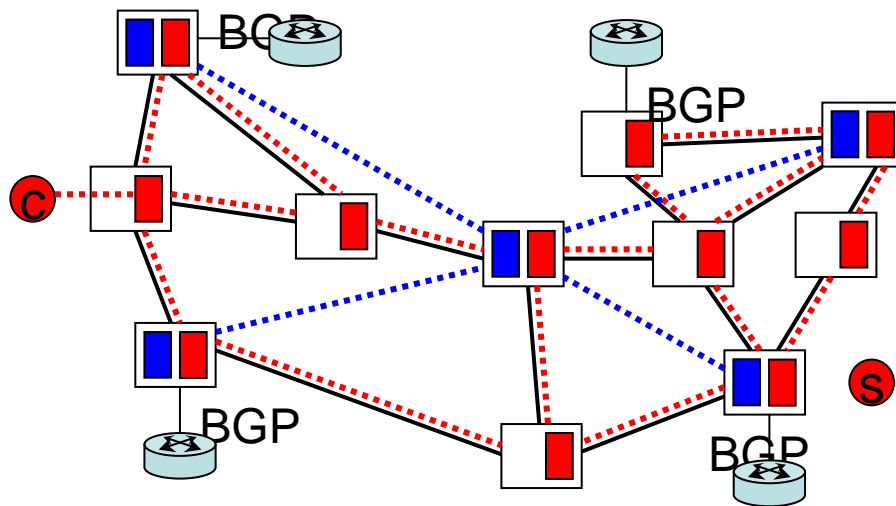# GENI related technologies #1

- VINI
  - Jennifer Rexford @ Princeton University
  - With PlanetLab, users can built an application level virtual network
  - VINI provides link level virtual networks using Packet Forwarding Engine, switches, filters, and virtual network interfaces, in the kernel

➡ **Opportunity for computer & network virtualization in software**

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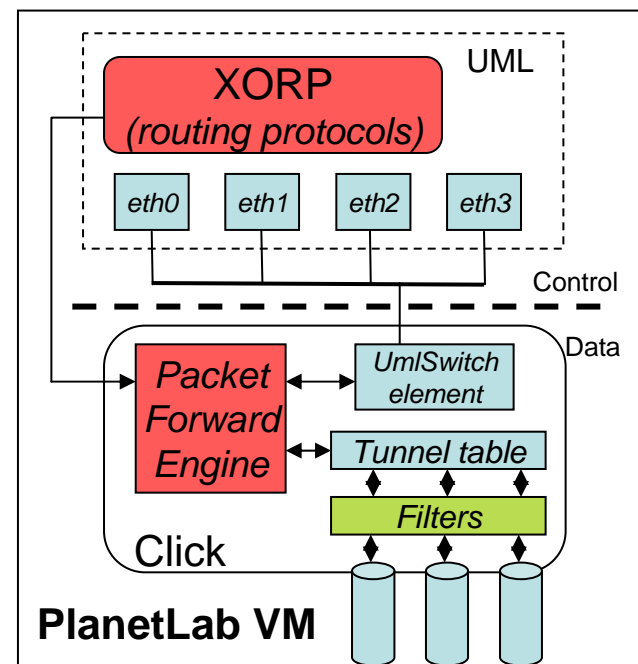
GENI related technologies #2

- Super Charge VINI
  - Jonathan Turner @ Washington University
  - Goal: Accelerate total forwarding performance of VINI
  - Scheme: Employs fast-path forwarding (cut-through) hardware combined with VINI where existing PlanetLab applications can run unchanged in slow path

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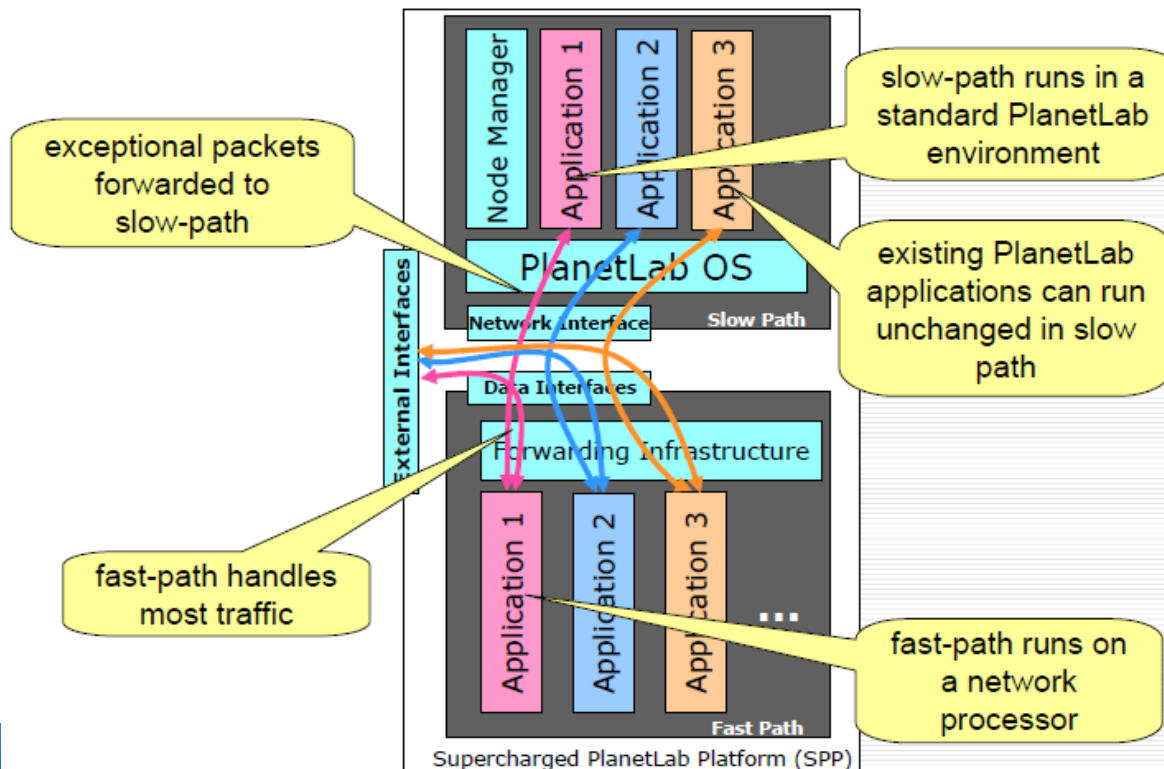
Key elements of future network research

- Lessons from NSF/GENI and FP7/4 WARD, TRILOGY
- Key elements of future network research
  - Open architecture
    - Easy to integrate modules for new features
  - Virtualization:
    - Dynamic grouping, partitioning and allocation of resources for ease of management
  - Modularity:
    - Dynamic in-service plug-in of software and hardware
  - Programmability
    - Evolve to new computer & network architecture
- These components will be key for multi-purpose research platform

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Expectations to GENI projects

- Expect to accelerate many trials of new internet research activities through instant globally virtualized networks.

- Original goal of GENI projects is to simply develop a research platform to find a next generation internet architecture, but we expect more.

- Expect future innovative FIND research, combined with specifically customized GENI node for it, to evolve to be a basis of next generation internet.
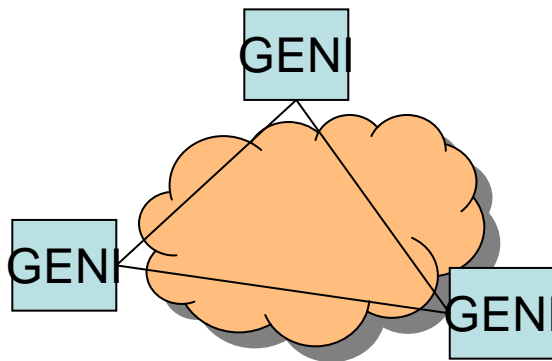
Evolved to 2nd Gen.

1st Generation:
Virtualized programmable overlay network
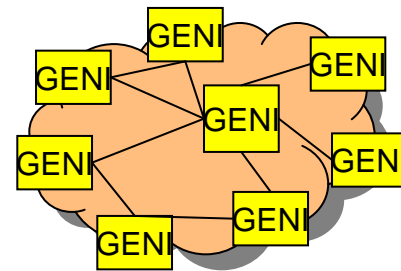
2nd Generation:
Next generation internet

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C&C concept
– The integration of Computers & Communications –

Keynote speech at Intelecom77 In Atlanta, on Oct.10th, 1977

Chairman, Koji Kobayashi

If I am asked about my vision for communications in the future, and if I am allowed to talk beyond my ability, my imagination goes to such extent that social needs for communications might be "to talk and see between any persons, at any time, at any place on the earth, in the early days of the next century."

Assuming that this comes true, all technology, communications, computer and television will be, and should be, integraterd for such needs at such time. And therfore, it is important to help developing countries to be able to participate in such a world telecommunications system.

- **The 30ᵗʰ year anniversary of C&C concept**
- **Expect that FIND research goal with GENI will achieve this "C&C" society.**

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NEC's research activity overview toward new generation network (NwGN)
- "Earthnet" project -

Earthnet

- '*Earthnet*' is the project name of NwGN R&D

- '*Earthnet*' provides a way to
  - Reduce the complexity
  - Reduce the resource (energy, money,…) consumption
  - Maximize the dependability

  of the new generation network

  by IT-Network virtualization technology

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Earthnet goal

- "Earthnet" is aiming at creating customized and optimized network infrastructure over:
  - Multiple carriers/ISPs that never have single common architecture
  - Heterogeneous IP and non-IP network technologies

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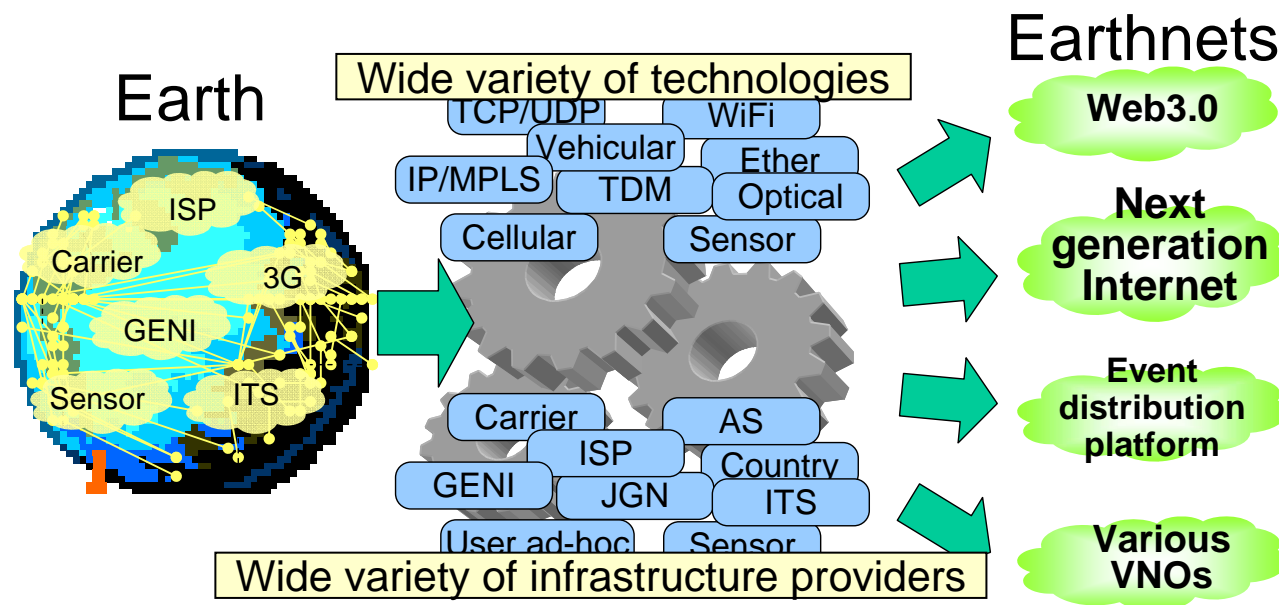
Earthnet architecture
– Virtualization and provisioning –

Service Layer

- Easy to develop new business virtual infrastructure
- Compiling service requirement to infrastructure spec

Logical infrastructure

Abstract Network (= InterX)

A document for a node written by Network Service Description Language

Real Network

A collection of hardware, software, firmware and links

Virtualized nodes

Physical nodes

Virtualized nodes

Physical infrastructure

Service requirement specification

SaaS operator
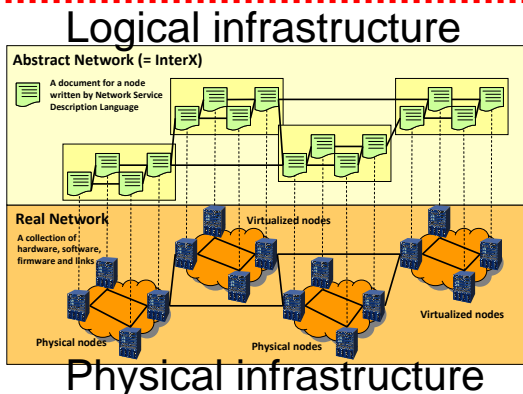
Emergency care service

Content distributor

SaaS | WebOS | Life log | ITS | Video streaming

Virtual network | Virtual network | Virtual network | Virtual network | Virtual network

Distributed computing infrastructure | Event processing infrastructure | Contents distribution infrastructure

Dynamic provisioning

Abstraction and isolation

Resource abstraction layer

- Dynamic provisioning of resources
- Abstraction and coordination of resources for customized services

Resource isolation & aggregation layer

- Isolation of network and computation resources for different services
- Direct and flexible access to variety of heterogeneous resources

TCP | TCP | PWE | TDM | CPU | Storage

IP

Ether

Optical

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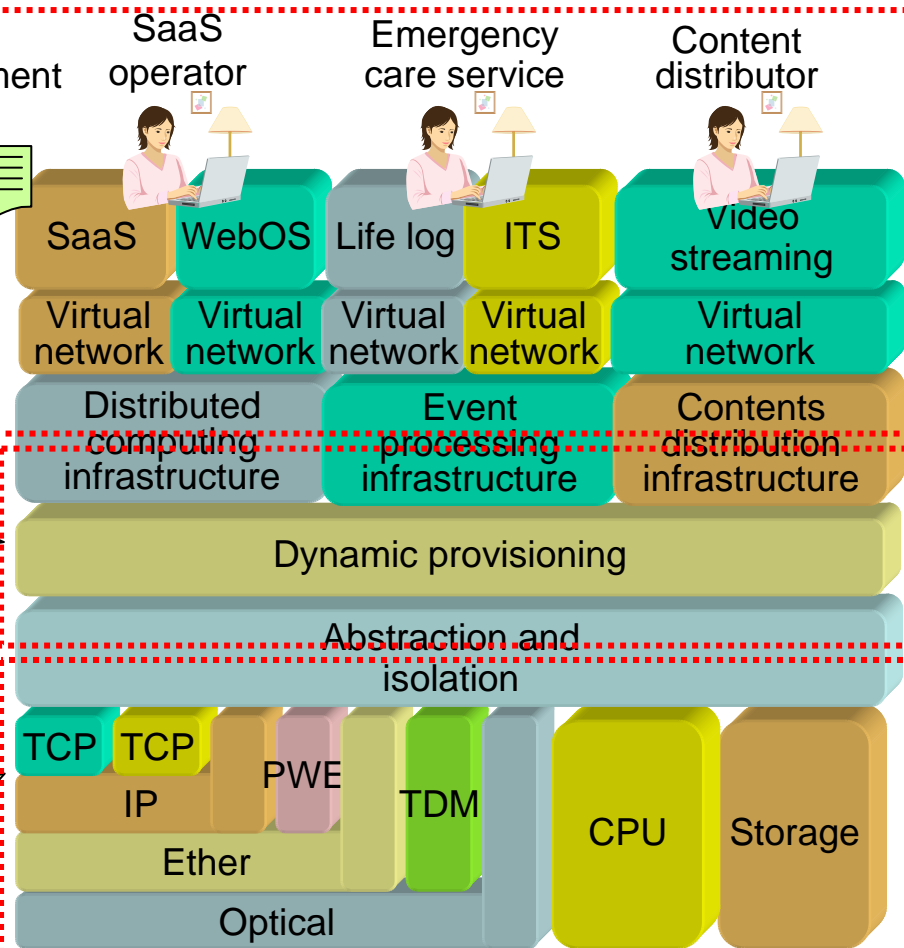
Virtualized Infrastructure

Per-service based Virtualized infrastructure

ITS

Life-log

Emergency care

Sensor

Tele-surgery

Grid
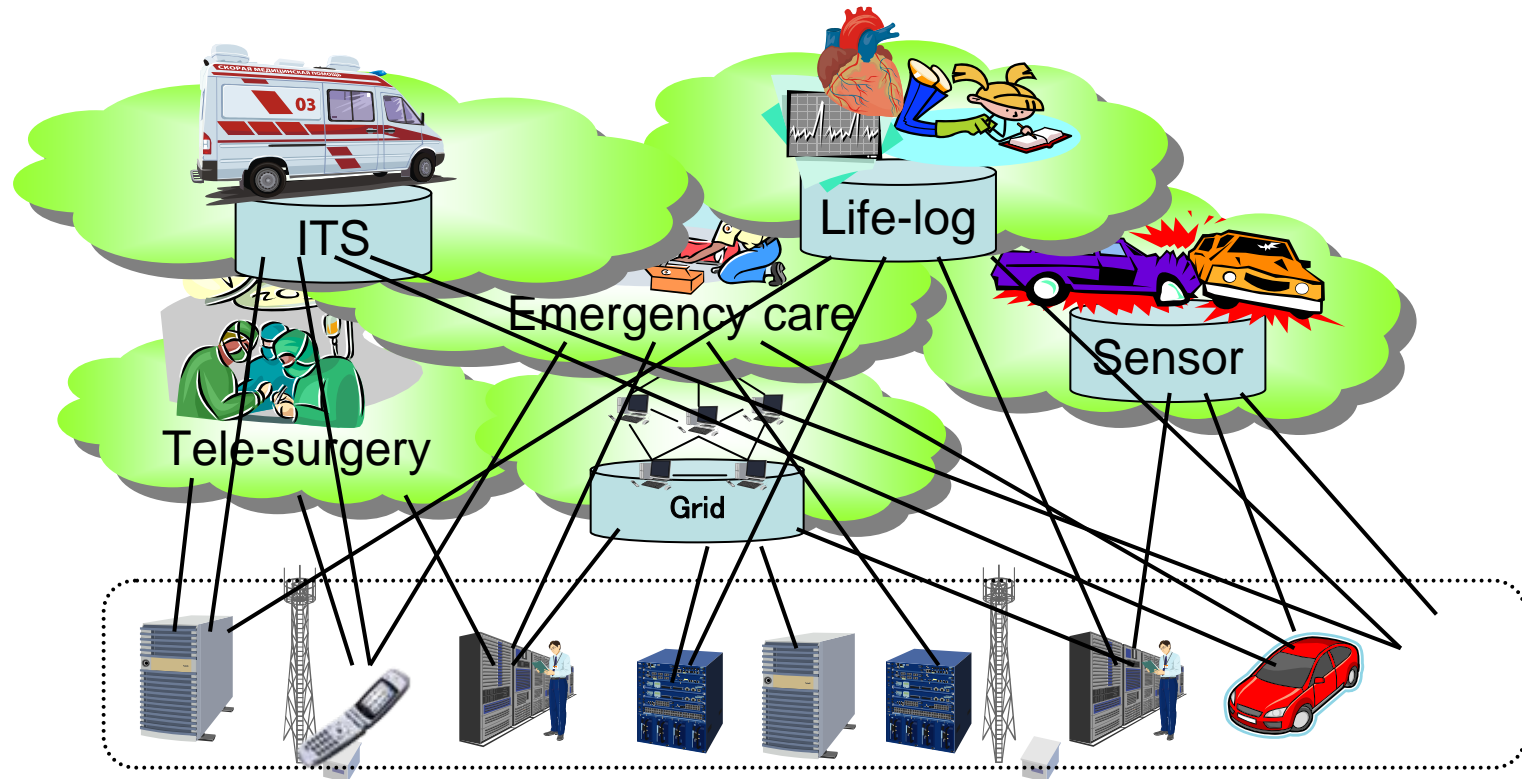
Virtualization of physical resource

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Earthnet design principle and basic node architecture

- Design principle
  - <u>Wire-speed operation and still programmable with realistic cost</u>
- Network-wide virtual node
  - Separation of data plane and control/management plane
  - Flexible configurations/programmability of control servers and nodes

New services
(=new control middleware)

1. VR-based virtualized Node

VM VM VM | Control plane MW VM | Data plane MW VM

Control server

2. Fast VM migration mechanism

➔ Scalable CPU and I/O

Overlay Networks

Node

Engine

3. Server-based intelligent processing with packet measurement and control

4. Virtualized data plane with HW assisted flow processing

➔ Scalable forwarding performance
➔ Scalable flow handling

Underlay Networks

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1. VR-based Virtualized node

- Standard I/F separation for Control plane/Data plane
- VM-based processing of Control-plane for providing flexible routing processing

Control plane

Data plane

CPU card

CPU card

Virtual Router A
Routing module
Dynamic NW Provisioning

Virtual Router B
Routing module
Dynamic NW Provisioning

Virtual Router C
XML
Dynamic NW Provisioning

Network resource control
Failure resource management
Traffic monitor control

Standard I/F

Standard I/F

Virtualized forwarding processing

パケット
フォワーディング
機構

Virtual Router (VR)
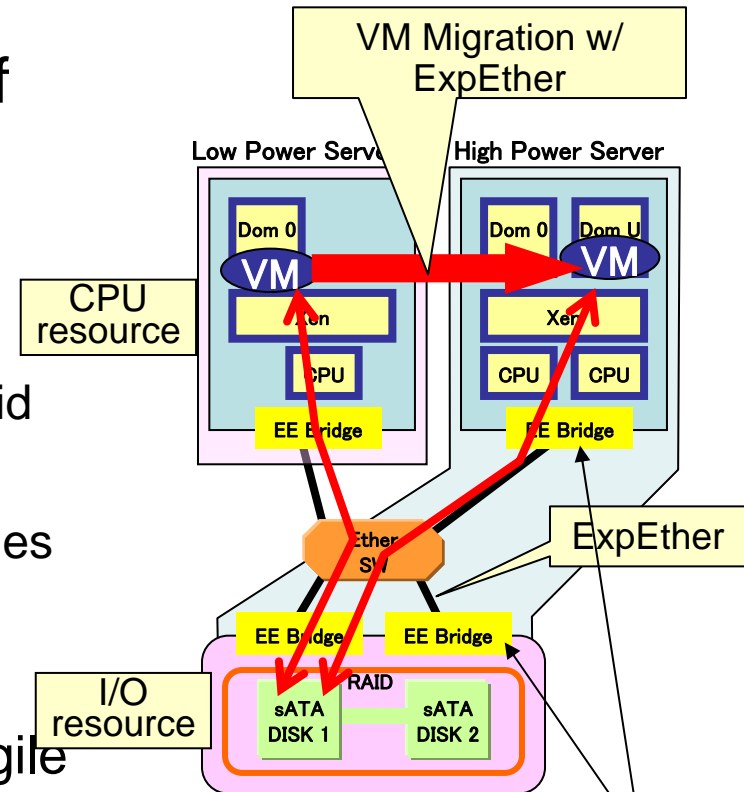
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2. Fast VM migration mechanism for scalable CPU and I/O resource

- Dynamic and agile reconfiguration of CPU and I/O resources

  - "ExpEther" provides PCI-Express interconnect over Ethernet

    - VM migration with ExpEther enables rapid server switching

    - I/O reconfiguration using ExpEther enables flexible CPU-I/O interconnection

  - Cooperation of VM migration and I/O reconfiguration provides dynamic and agile resource reconfiguration

➔ Virtualization of data-center resources

➔ Virtualization of control server resources

VM Migration w/ ExpEther

Low Power Server   High Power Server

Dom 0 — VM   Dom 0 — Dom U VM

CPU resource   Xen   Xen
                    CPU   CPU   CPU

EE Bridge   EE Bridge

Ether SW   ExpEther

EE Bridge — EE Bridge

I/O resource   RAID
                    sATA DISK 1   sATA DISK 2

PCIex4–10GbE bridge

PCIx1–1GbEx2 bridge

3. Server-based intelligent network processing with packet measurement and control

Active cache control
Periodical (packet-by-packet) cache replace based on network measurement
Significantly reduce flow cache size
Minimize cache miss-hit

Performance measurement
Packet loss rate estimation
TCP: sampled dup-ACK packets
UCP/RTP: hash-based sampling

VM | VM | VM | Flow control | Flow monitor

Control server

Virtual machine monitor
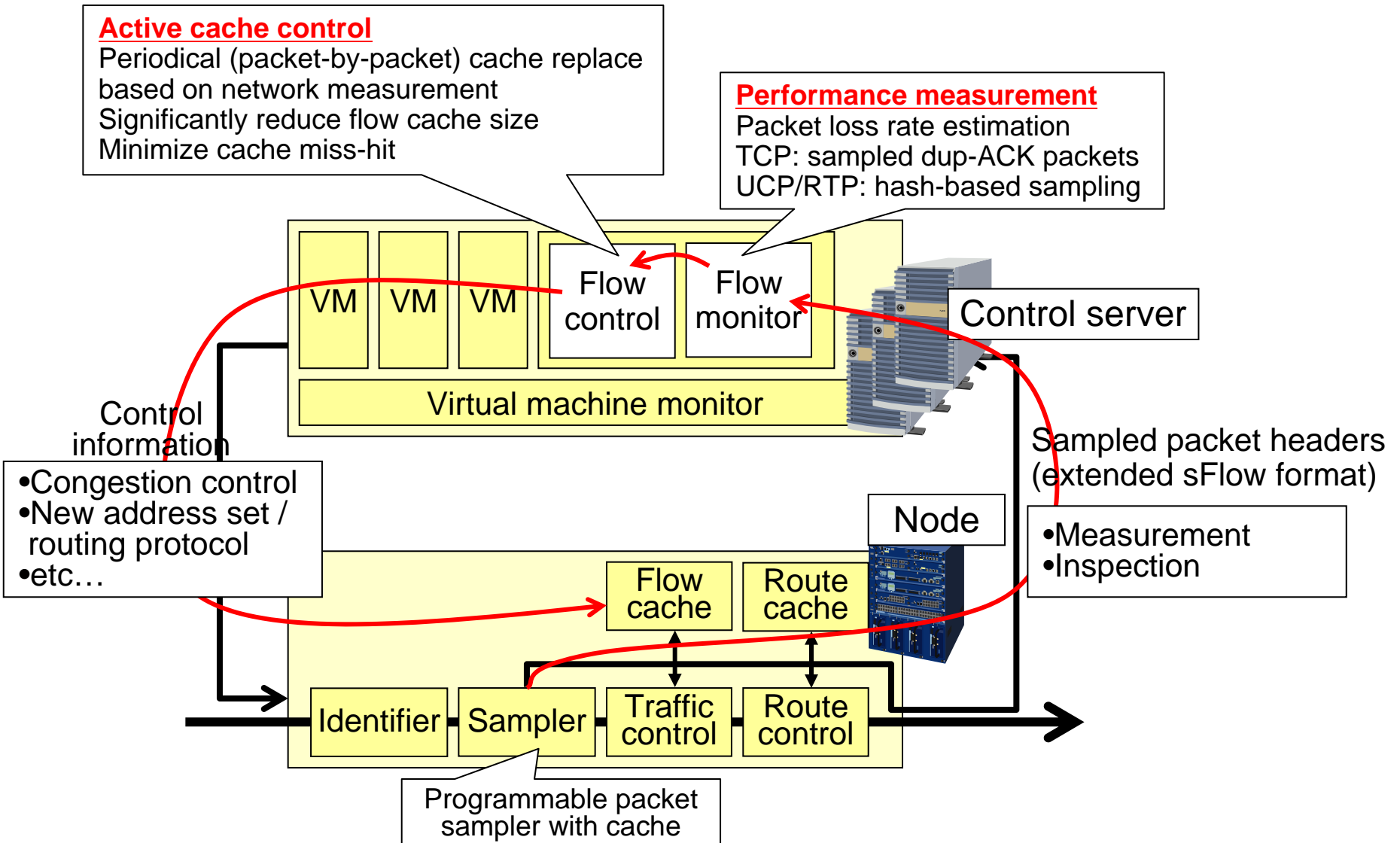
Control information
- Congestion control
- New address set / routing protocol
- etc…

Sampled packet headers (extended sFlow format)

Node

- Measurement
- Inspection

Flow cache | Route cache

Identifier | Sampler | Traffic control | Route control

Programmable packet sampler with cache

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4. Virtualized data plane via HW assisted scalable flow processing – 10Gbps IDS Flexible Platform for Network Security

Intel Architecture Server
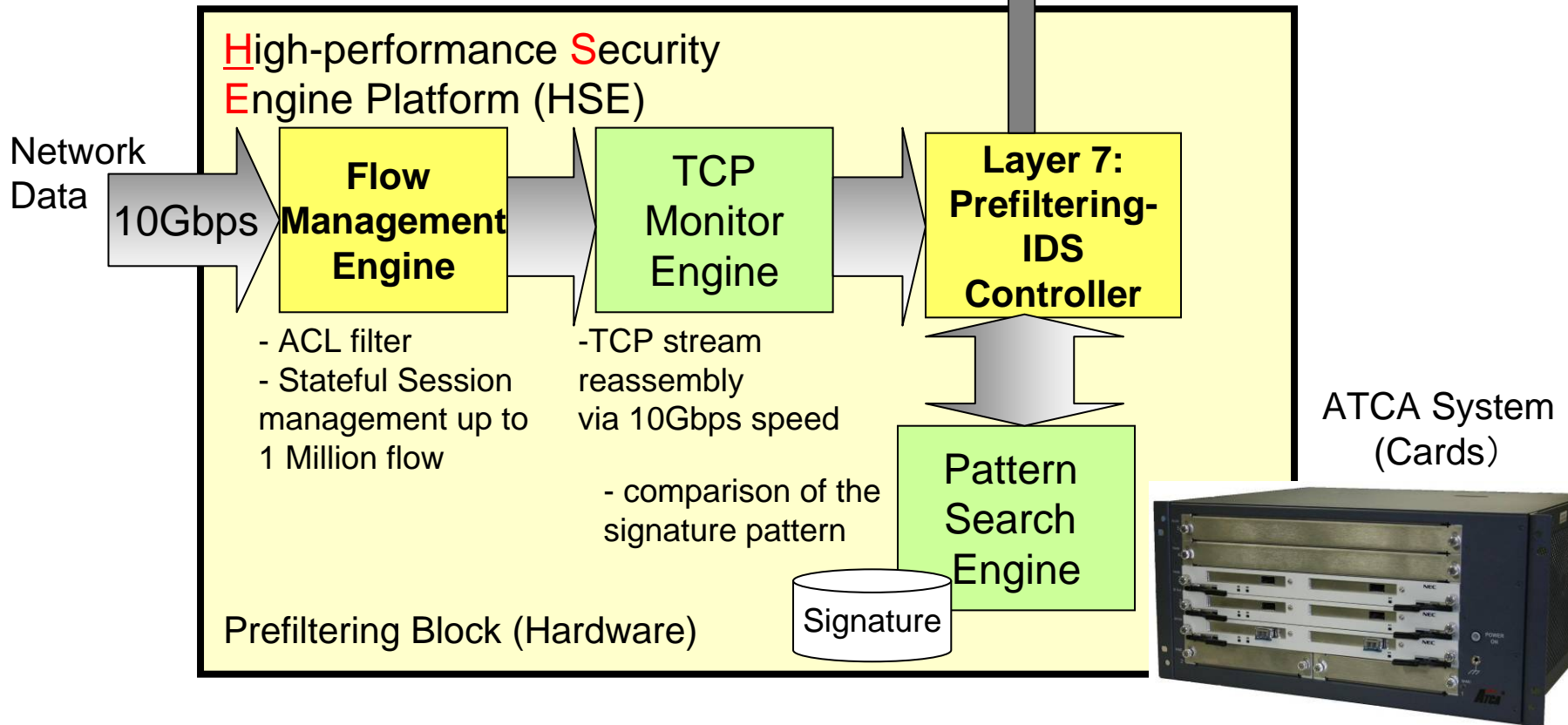
Detail Checking (Software)

Application -- "Psnort" (Modified Snort)
"lib*h*cap" (=libpcap customized for HSE Platform)
Device Driver for HSE system
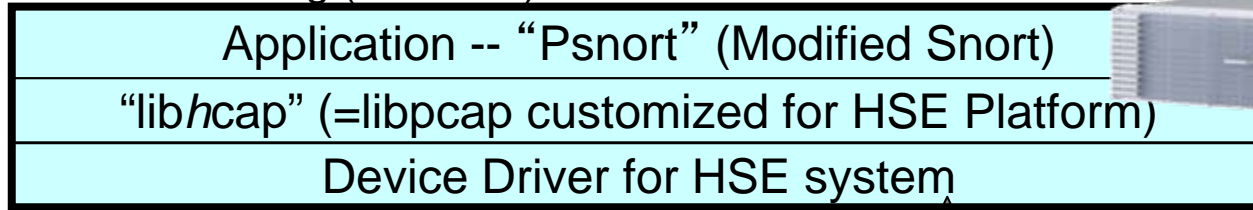
PCI-Express

Suspicious Traffic Data

High-performance **S**ecurity **E**ngine Platform (HSE)

Network Data
10Gbps

Flow Management Engine
- ACL filter
- Stateful Session management up to 1 Million flow

TCP Monitor Engine
-TCP stream reassembly via 10Gbps speed

Layer 7: Prefiltering-IDS Controller

- comparison of the signature pattern

Pattern Search Engine

Signature

Prefiltering Block (Hardware)

ATCA System (Cards）

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Conclusion

- Introduced new generation network related research overview of USA, EU and Japan

- Expectations to GENI activities for future internet beyond a simple testbed system

- Introduced NEC's research vision "Earthnet", and explained several related research activities as a first step.

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