Evolution of virtualization technology for the future optical internetworking

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Agenda

- Networking evolutions
- Network resource virtualization for telecom operator
  - High-level architecture
  - Design of prototypes
- Demonstration
  - Policy-based E2E quality control
  - Resource scheduling
  - Distributed messaging flow
- Virtualization of functional modules
  - High-level architecture
  - Cache function control
- Conclusion
Networking evolutions
-From consolidation to customization-

~Today
- IP/Ethernet
- ADM
- TDM
- ATM

“NGN”
- IP/Ethernet

Beyond NGN
- Virtual network
- Storage (e.g. cache)
- Data processing (e.g. compression)

Transport architecture

Networking technologies
- Control plane (MPLS, GMPLS)
- Session/flow control (IMS, RACF, BGF)
- Virtualization (Network resource, Functional modules)

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Virtualization: Advantages

- **Short delivery time**
  - Prompt coordination of heterogeneous infrastructures

- **Low cost**
  - Good reusability and high utilization of infrastructures

- **Flexibility**
  - Customized network and other building blocks
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Virtualization: Grid approach

From G-lambda project (www.g-lambda.net)

Applications

Grid Application

Grid Portal

Grid Resource Scheduler

Computing Resource Managers

Network Resource Managers

Middleware for virtualization

Resource/Fabric

Computers

Reserved time: hhmmss - hhmmss

Duration: x min
Deadline: hhmmss

Site A

Site B

Site C

1Gbps

1Gbps

2Gbps

2Gbps

10

5

1

5

2Gbps

1Gbps

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6
Seeds of virtualization in NGN

From ITU-T Rec. Y.2012

IMS (IP Multimedia Subsystem)

RACF: Resource virtualization for IMS
Network resource virtualization
- Based on Grid approach-

- Virtualization: NRM as a virtualization engine for various resources
- Common API: Network service interface (NSI) for coherent accessibility
- Business process: Harmonization to the business processes

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Network as a service in SOA

- Loosely coupled
  - Tolerant to any change of backend systems (Good reusability)
- Implementation environment
  - Rich frameworks and development tools (Lower development cost)
- Business driven work flow
  - Easy integration to the existing business process
Virtualization of optical networks

- Resource management middleware proposed by KDDI R&D labs
- NRB: **Single point of contact** to service control layer
- NRM: **Distributed management** to cover E2E
Design of virtualization engines

- **Hierarchical** path computation with NRB-NRM load sharing resource management architecture
  - NRB: Abstracted topology handling and parallel transaction handling
  - NRM: Detailed topology handling, resource scheduling and deciding resource allocation policy

- **Universal WSI** for reconfigurable extensibility

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*WSI: Web Services Interface*
GE-PON virtualization

- Management policies and mechanisms
  - Policy-based CIR/PIR provisioning for each LLID (<4 per user)
  - Time-scheduled bandwidth management of shared PON link
    - Call admission control and degeneration management
    - On-demand and scheduled services
  - DBA* for unused bandwidth

*DBA: Dynamic Bandwidth Allocation
RPR virtualization

- Management policies and mechanisms
  - Policy-based CIR/EIR provisioning for each VPLS path (<1023 total)
  - Classification of services with VLAN-ID and QoS
  - Time-scheduled bandwidth management of shared RPR link
    - Call admission control and degeneration management
    - On-demand and scheduled services
IP/lambda virtualization

- Management policy and mechanisms
  - Request-based adaptive LSP allocation
    - In-advance path computation with breadth-first search
    - LSP selection meeting latency and bandwidth requirements
  - Time-scheduled bandwidth management with per-link basis
    - Admission control and degeneration management
    - On-demand and scheduled services

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**Different link attributes**

- Link ID
  - A-B#1
  - B-C#1
  - C-D#1
  - D-E#1
  - B-I#1
  - J-I#1
  - J-I#2
  - I-G#2
  - G-F#2

<table>
<thead>
<tr>
<th>Path</th>
<th>Resource scheduling table per link</th>
</tr>
</thead>
<tbody>
<tr>
<td>A-B#1</td>
<td>2 Gbit/s, 2.4 Gbit/s</td>
</tr>
<tr>
<td>B-C#1</td>
<td>2 Gbit/s</td>
</tr>
<tr>
<td>C-D#1</td>
<td>2 Gbit/s</td>
</tr>
<tr>
<td>D-E#1</td>
<td>2 Gbit/s</td>
</tr>
<tr>
<td>B-I#1</td>
<td>2.4 Gbit/s</td>
</tr>
<tr>
<td>J-I#1</td>
<td>2.4 Gbit/s</td>
</tr>
<tr>
<td>J-I#2</td>
<td>500 Mbit/s</td>
</tr>
<tr>
<td>I-G#2</td>
<td>500 Mbit/s</td>
</tr>
<tr>
<td>G-F#2</td>
<td>500 Mbit/s</td>
</tr>
<tr>
<td>500M path (J-I-G-F)</td>
<td>500 Mbit/s</td>
</tr>
</tbody>
</table>

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Demonstration

- Southbound implementation of NRMss
  - A-NRM: CLIs of OLT, C-NRM: CLI of router, M-NRM: CORBA of EMS
- Typical server platforms for NRB and NRMss
  - Memory: 768 Mbytes
  - CPU: 2.4 GHz

Typical server platforms for NRB and NRMss

- Memory: 768 Mbytes
- CPU: 2.4 GHz

Demonstration environment

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Policy-based E2E quality control

- Pre-planned (DiffServe-based)
  - Entire services are degraded without admission control and BW management
  - Degradation of entire video services

- NRM/NRB-controlled
  - E2E CIR is assured on-demand
  - Voice and video services are preserved

<table>
<thead>
<tr>
<th>Traffic</th>
<th>Typical service</th>
<th>BW profile</th>
</tr>
</thead>
<tbody>
<tr>
<td>ToS=6</td>
<td>Voice</td>
<td>90kbps*(200 flows)</td>
</tr>
<tr>
<td>ToS=5</td>
<td>Real-time video</td>
<td>6Mbps*(N flows)</td>
</tr>
<tr>
<td>ToS=0</td>
<td>Data</td>
<td>5Mbps*(140 flows)</td>
</tr>
</tbody>
</table>

Pre-planned (DiffServe) NRM/NRB-controlled

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Resource scheduling

- **Successful** hierarchical path computation and scheduling
  - Detailed route adaptation by C-NRM (Request 3)
  - Abstracted rerouting by roll back operation of NRB (Request 4)

<table>
<thead>
<tr>
<th>Request #</th>
<th>EP 1</th>
<th>EP 2</th>
<th>Bandwidth (M bit/s)</th>
<th>Latency (ms)</th>
<th>Scheduled time frame</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Rtr1</td>
<td>Rtr2</td>
<td>500</td>
<td>8</td>
<td>10:00 - 11:00</td>
</tr>
<tr>
<td>2</td>
<td>CPE1</td>
<td>EP1</td>
<td>300</td>
<td>10</td>
<td>12:00 - 13:00</td>
</tr>
<tr>
<td>3</td>
<td>CPE2</td>
<td>EP2</td>
<td>300</td>
<td>22</td>
<td>14:00 - 15:00</td>
</tr>
<tr>
<td>4</td>
<td>CPE3</td>
<td>EP3</td>
<td>350</td>
<td>10</td>
<td>16:00 - 17:00</td>
</tr>
<tr>
<td>5</td>
<td>CPE3</td>
<td>EP1</td>
<td>300</td>
<td>7</td>
<td>16:00 - 17:00</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Request #</th>
<th>Initial route selected by NRB</th>
<th>Final assigned route (w/ assist of NRMs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Rtr1-Rtr2</td>
<td>Rtr1-XC1-XC2-Rtr2</td>
</tr>
<tr>
<td>2</td>
<td>CPE1-OLT1-RPR1-RPR4-Rtr1-Rtr2-RPR8-RPR6</td>
<td>CPE1-OLT1-RPR1-RPR4-Rtr1-XC1-XC2-Rtr2-RPR8-RPR6</td>
</tr>
<tr>
<td>3</td>
<td>CPE2-OLT1-RPR1-RPR4-Rtr1-Rtr2-RPR8-RPR7</td>
<td>CPE2-OLT1-RPR1-RPR4-Rtr1-XC1-XC3-XC4-XC2-Rtr2-RPR8-RPR7</td>
</tr>
<tr>
<td>4</td>
<td>CPE3-OLT1-RPR1-RPR4-Rtr1-Rtr2-RPR8-RPR7</td>
<td>CPE3-OLT1-RPR1-RPR4-Rtr3-XC3-XC4-Rtr4-RPR8-RPR7</td>
</tr>
<tr>
<td>5</td>
<td>CPE3-OLT1-RPR1-RPR4-Rtr1-Rtr2-RPR8-RPR6</td>
<td>CPE3-OLT1-RPR1-RPR4-Rtr1-XC1-XC2-Rtr2-RPR8-RPR6</td>
</tr>
</tbody>
</table>

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Distributed messaging flow

- Successful roll back with two-phase commit (request #4)
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Virtualization of functional modules

Functional modules building blocks

- Load balancing
- Encap
- Compress
- DPI
- Protocol
- Redundancy
- Firewall
- Security
- Memory

On-demand/work-flow

FCoE + VPN

CIFS optimization + Compress

Load balancing + SBC

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Secured FCoE
WAN boost
Scalable VoIP media GW
Virtualization of functional modules

NRB: Network Resource Broker
NRM: Network Resource Manager

IMS
SDP
Network service clients
Configuration system
Inventory
Traffic
Alarm

Function Manager

Network resource management system
Orchestration
SOA-bus
Virtualization

Data center

Functional modules

Access
EMS
Metro (Ring)
Packet ADM
Video-conference
P2P
IPTV
VoIP
CPE
OLT

Core (Mesh)

Functional modules

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Conclusion

- Virtualization of network resources
  - Consideration of heterogeneity
  - Open API
  - SOA-based design for business process

- Network resource management is a key
  - NRM and NRB
  - BPEL-based work flow management
  - Policy-based quality control
  - Scheduling

- Functional modules virtualization
  - Lego ® block networking architecture
  - Customized networking

- Future studies
  - Involvement of various functional modules
  - Interworking with network resource management

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