# Address-Translation-Based Network Virtualization

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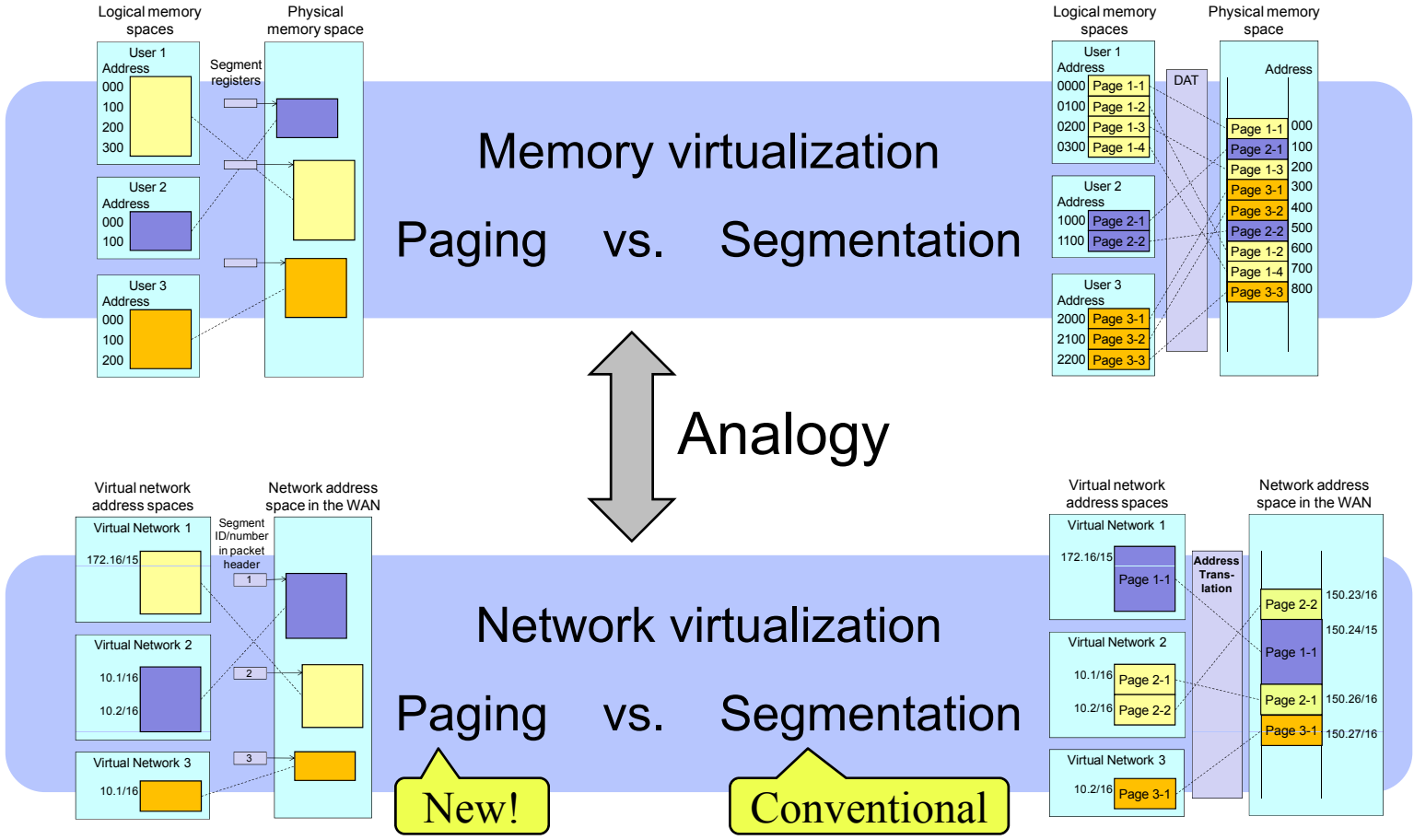
# Introduction

- **Network virtualization**
  - isolates multiple services or communities while using the same hardware.
  - enables users to create their own wide-area networks.
  - can simplify network architecture and protocols because it can be independent from conventional network.
- **Conventional network address translation (NAT)**
  - causes complexity and “headaches”.
  - plays an important role in real-world networks.
    - when the number of available IP addresses is less than required.
    - when there are IP addresses that should be hidden from the global network.
- **We will show *Address-Translation-based network Virtualization* (ATV)**
  - which is a relatively new method of network virtualization.

# Two Virtualization Architectures

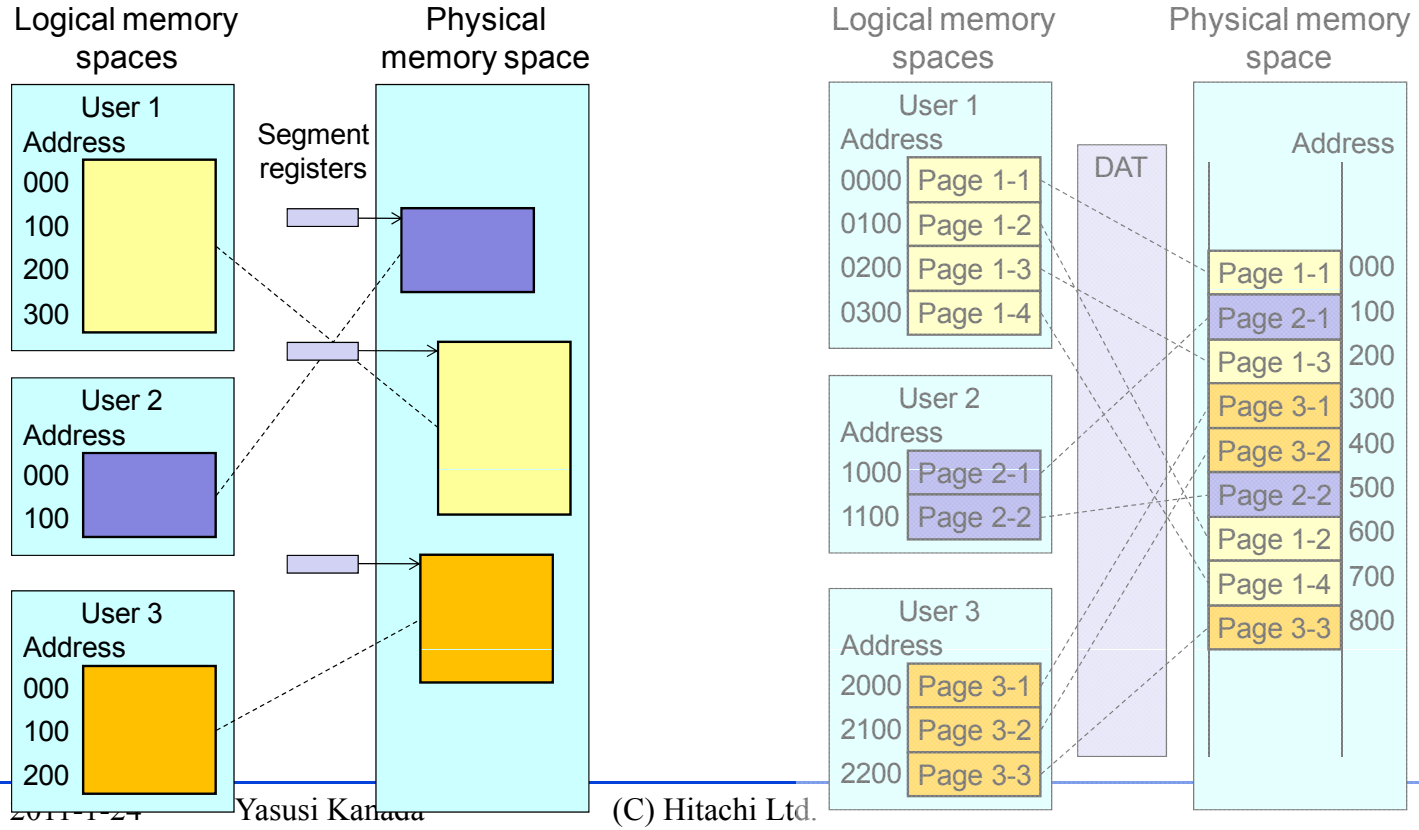
- **Virtualization technology was first developed for virtualizing computer memory.**
- **Analogy between memory and network virtualization:**



# Paging and Segmentation in Main Memory

## ■ Segmentation

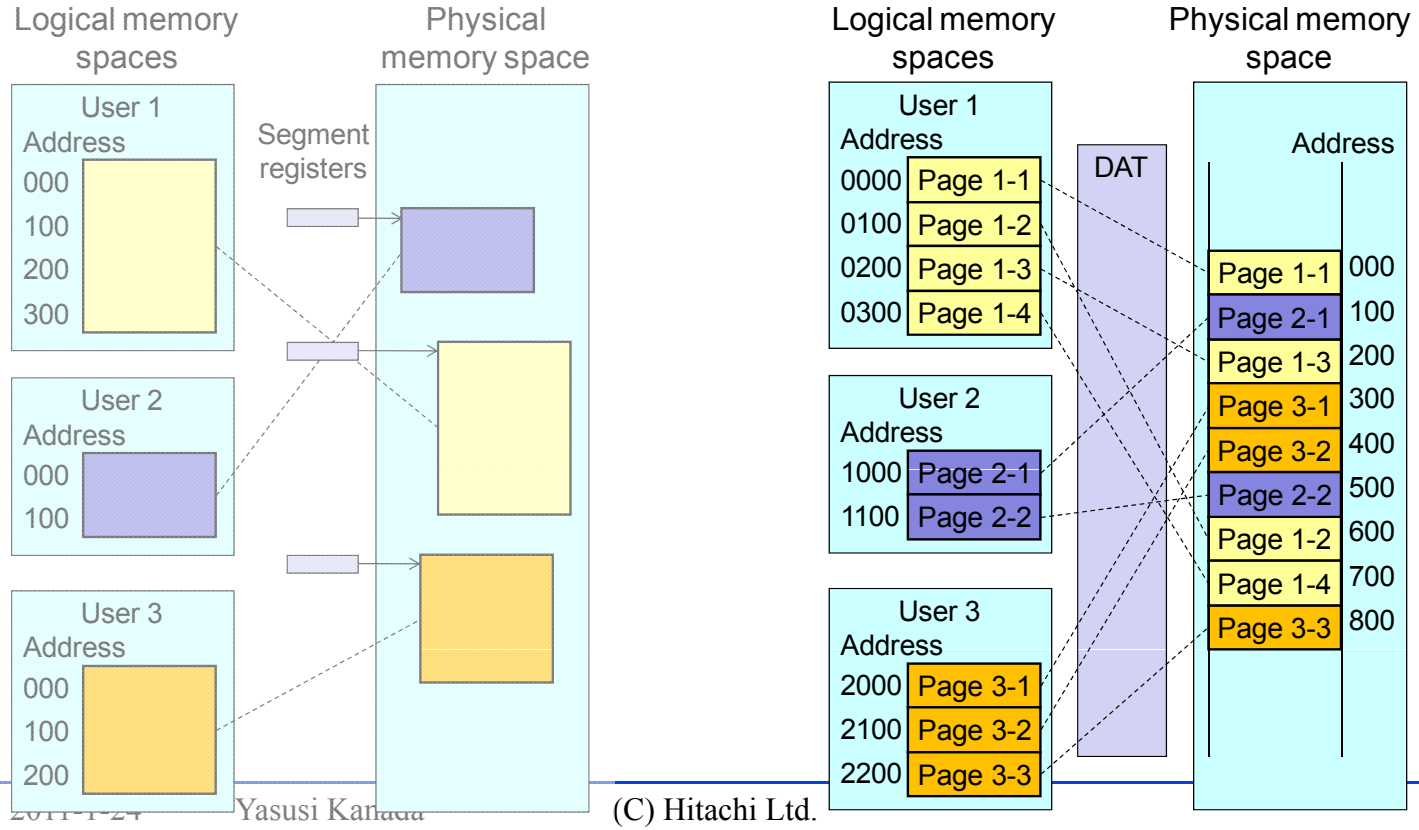
- ◆ The memory space is divided into logically separated and variable-sized segments and each user uses a segment.
- ◆ Logical and physical memories are mapped to each other by using segment(register)s.
- ◆ Address = **<Segment_number, Displacement>**.



# Paging and Segmentation in Main Memory (cont'd)

## ■ Paging

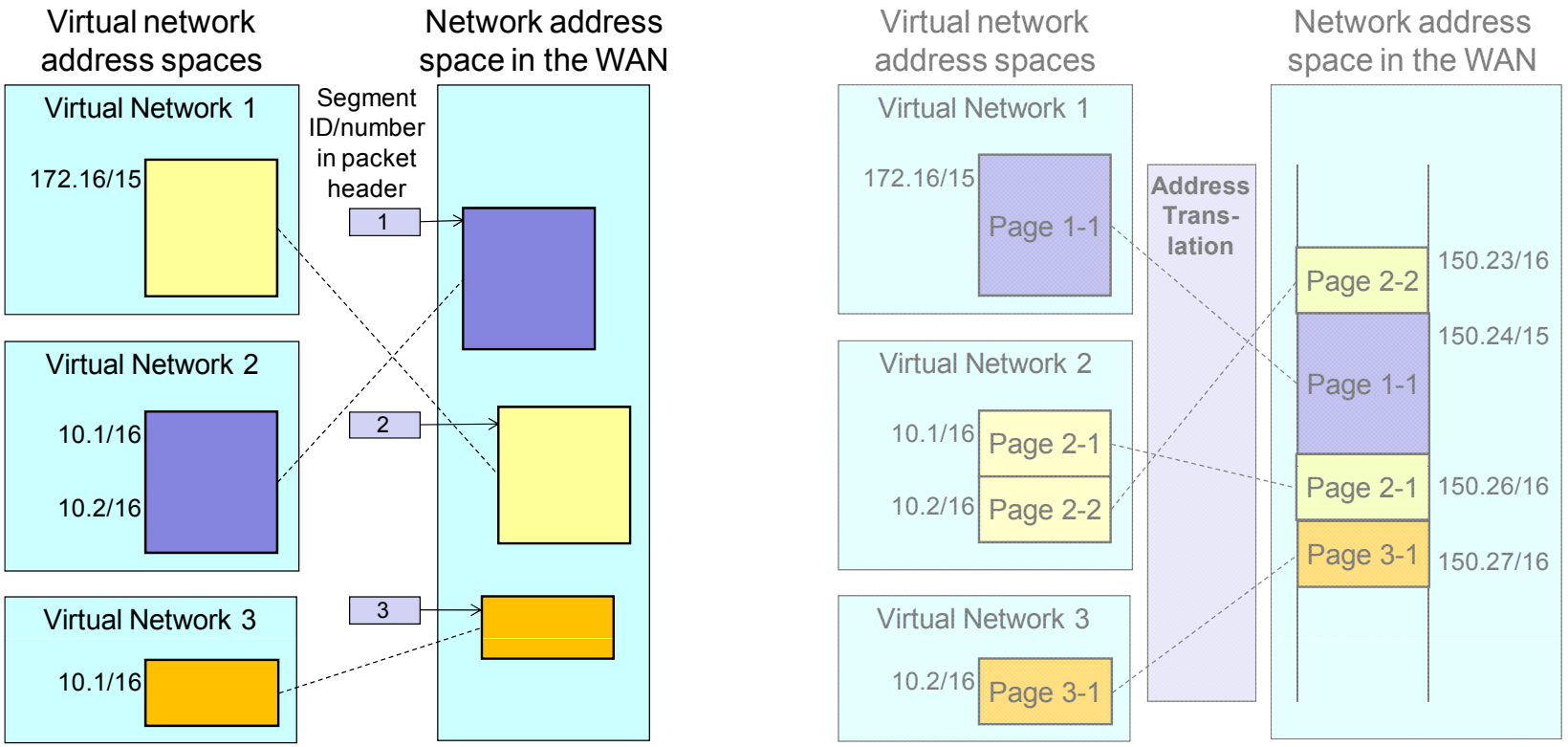
- ◆ The memory space is divided into fixed-size pages.
- ◆ The pages of all the users of a computer are mapped into a single large physical address-space.
- ◆ Logical memory is mapped to physical memory by DAT (dynamic address translation).



# Paging and Segmentation in Network

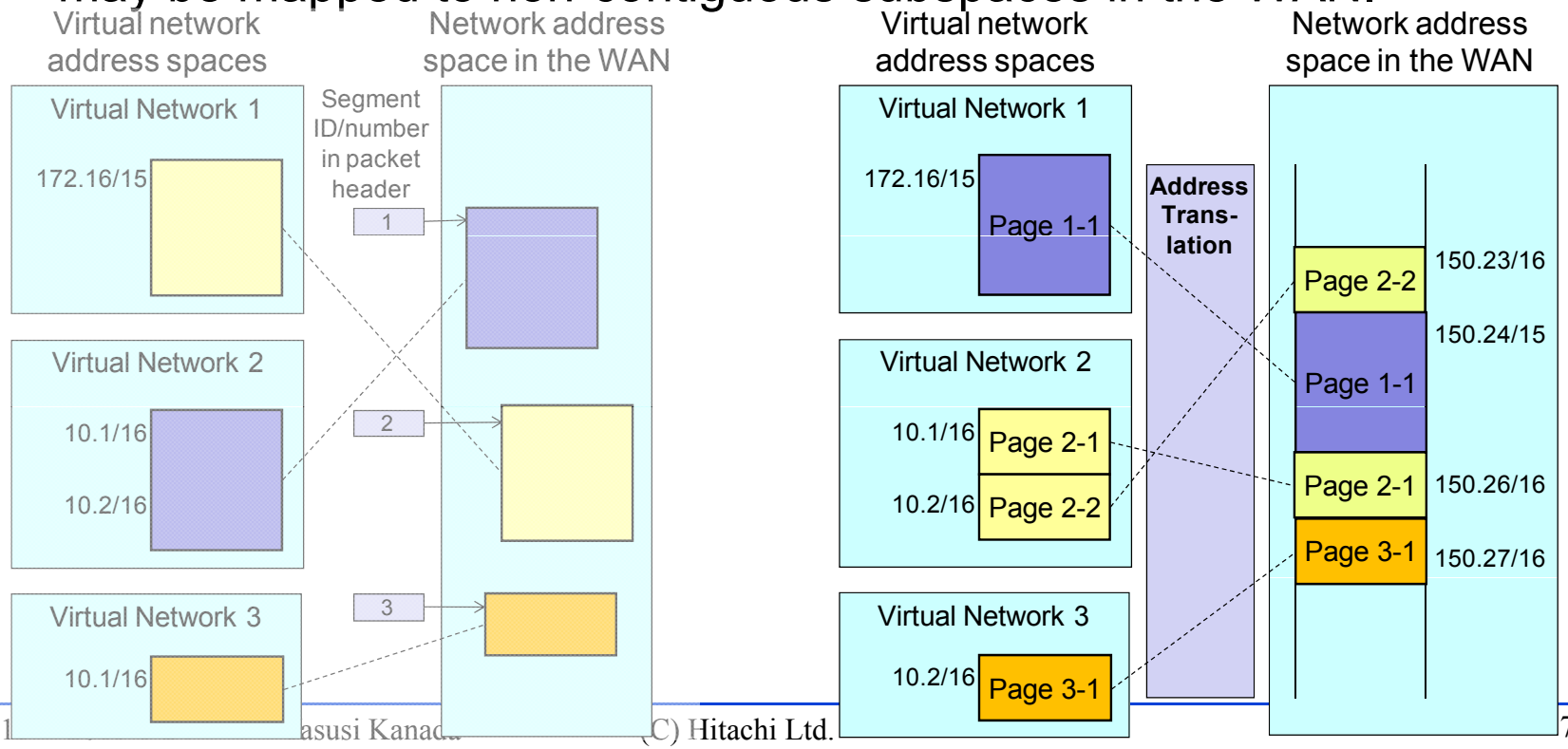
## ■ Network segmentation

- ◆ distinguishes every network object by **<Segment_identifier, OID>**
  - Segment identifiers are VPN numbers or names, or VLAN identifiers.
  - OIDs (object identifiers) are usually addresses of objects in the network.
- ◆ is widely used in VPNs and experimental virtual networks.



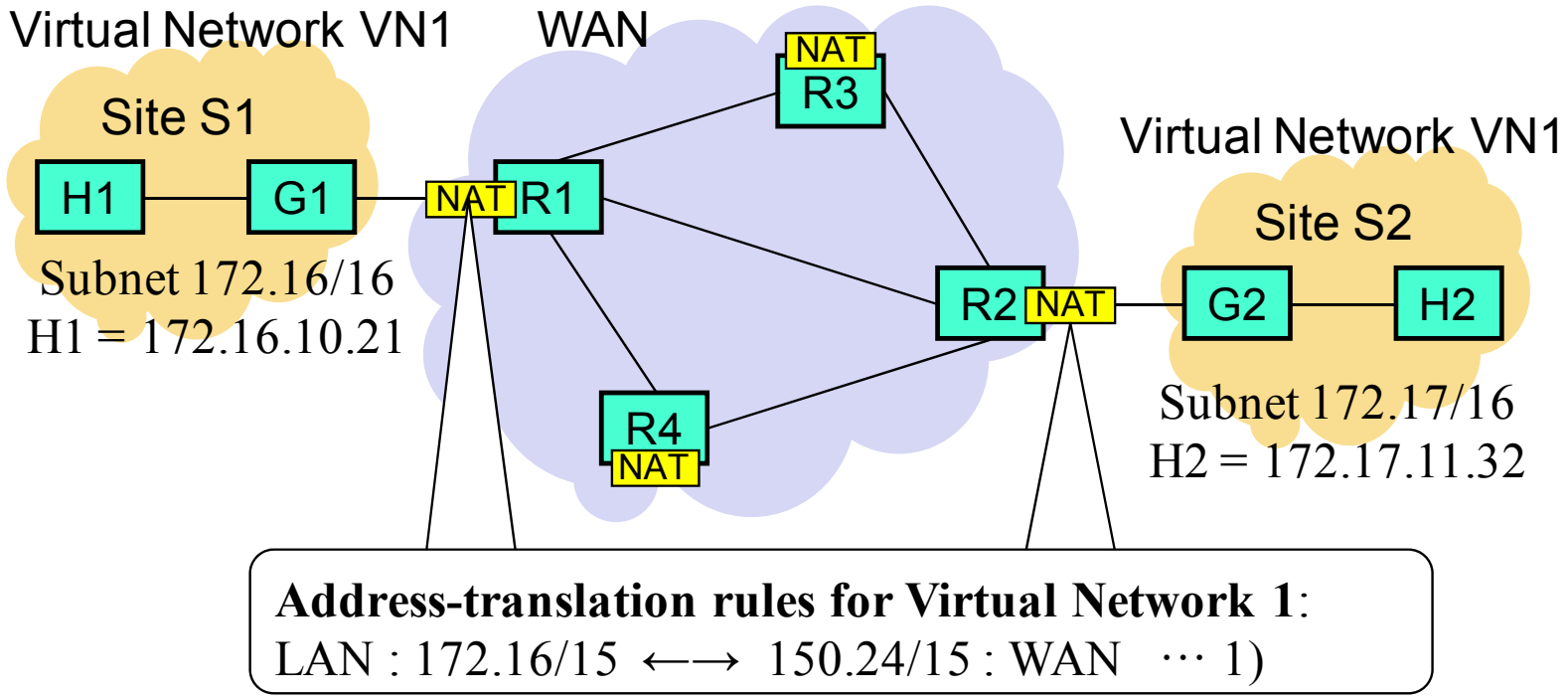
# Paging and Segmentation in Network (cont'd)

- **Network paging (or ATV** (address-translation-based virtualization)**)**
  - A VN architecture that distinguishes every network object in all VNs by a single unique address in "physical network" (or WAN).
  - Local addresses of objects are mapped to the unique addresses by using an address translation (a type of NAT).
  - A virtual-address space may be divided into multiple pages and may be mapped to non-contiguous subspaces in the WAN.



# Example: Intranet-type Communication

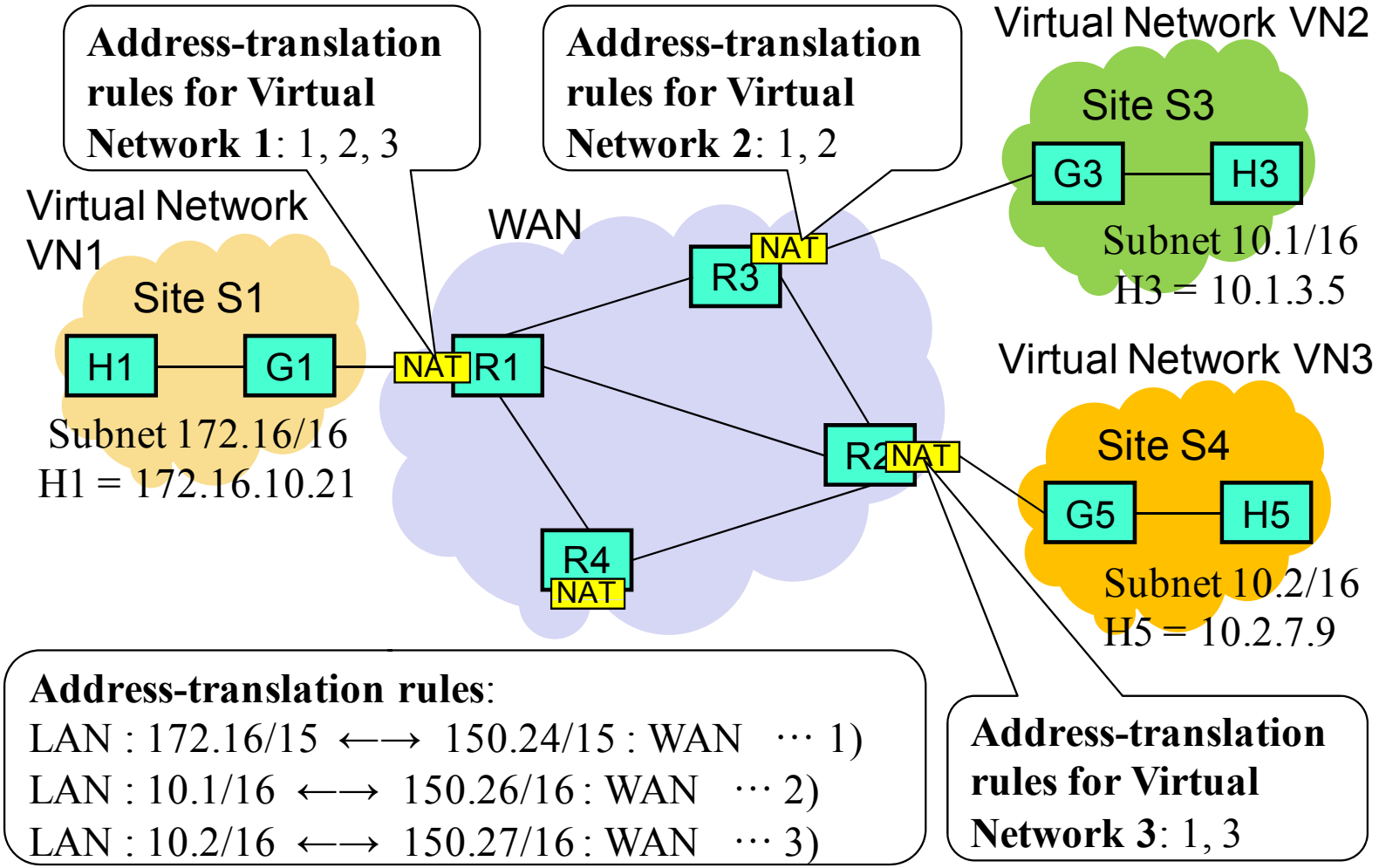
- **Only one page (a single rule) is used.**




- **Required conditions**
  - **Identity of addresses**: OIDs for the same object must be identical in all the sites.
  - **Isolation of VNs**: No other VN may use the same page (same address range) in the WAN.

# Example: Extranet-type Communication

- **Hosts in S1 can communicate with hosts at S1 and S2.**
- **Hosts in S3 can communicate only with hosts at S1. …**



# Advantages of ATV

- **No overhead and less redundancy in packets**
  - No extra field, such as segment identifier, is required.
- **Availability of WAN functions**
  - Virtualized packets may utilize WAN functions because the packets are not capsuled.
  - E.g. If the WAN is an IP network, the functions of ICMP or routing may be useful.
- **Availability of NAT implementations**
  - Conventional NAT implementations may be used.
    - E.g. A high-performance carrier-grade (large-scale) NAT may be used.
  - Implementations may be modified because conventional NAT and address translation required for virtualization are different.

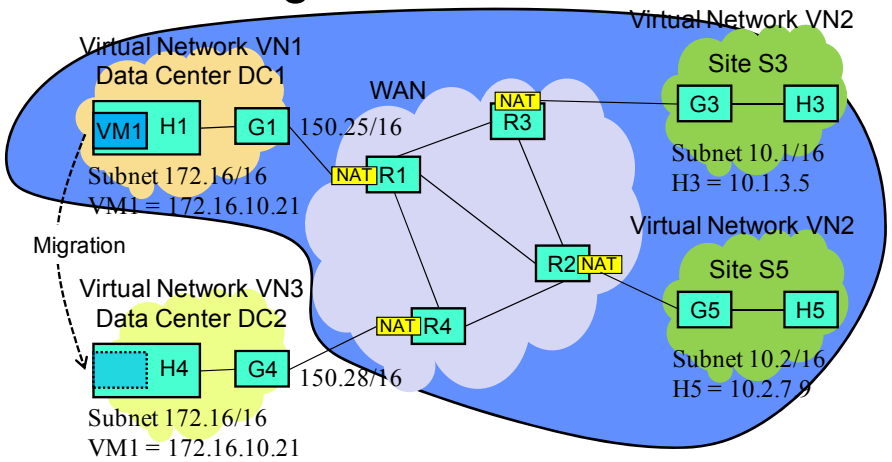
# Disadvantages of ATV

- **Potentially large-memory-size and slow rate of processing**
  - It requires a translation-rule table or translation logic.
- **Restriction on OID formats**
  - Address mapping may cause restrictions on the syntax or semantics of the OIDs (addresses).
- **Possible conflict with WAN function**
  - VN functions may cause conflict with WAN functions because the packets are not capsuled.
  - E.g. If the WAN is an IP network, address translation may make routing work in an unexpected way on the VN.

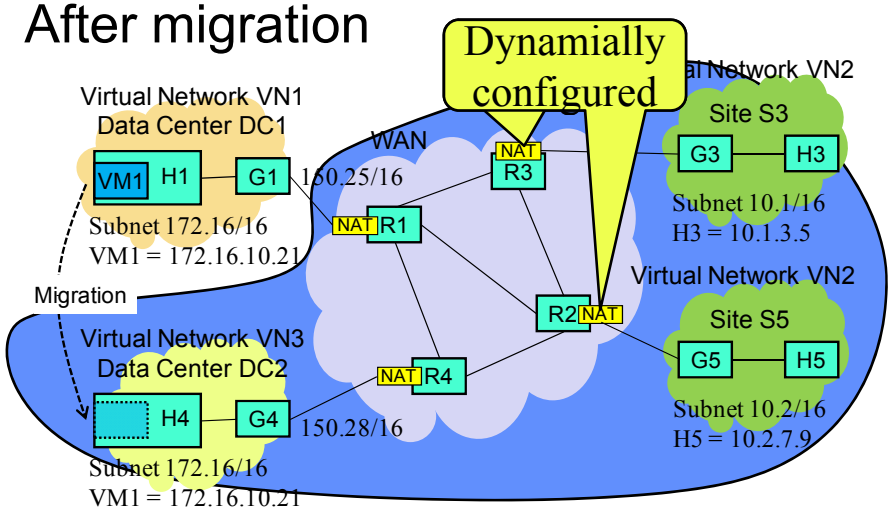
# Application To VM Migration (an experiment)

- **The feasibility of ATV was tested using wide-area live-migration example.**
- **Wide-area live migration of VMs between data centers**
  - can solve problems such as load balancing, disaster avoidance and recovery, and power saving.
  - causes “address warping” problem, which can be solved using ATV.
- **Method**

Before migration

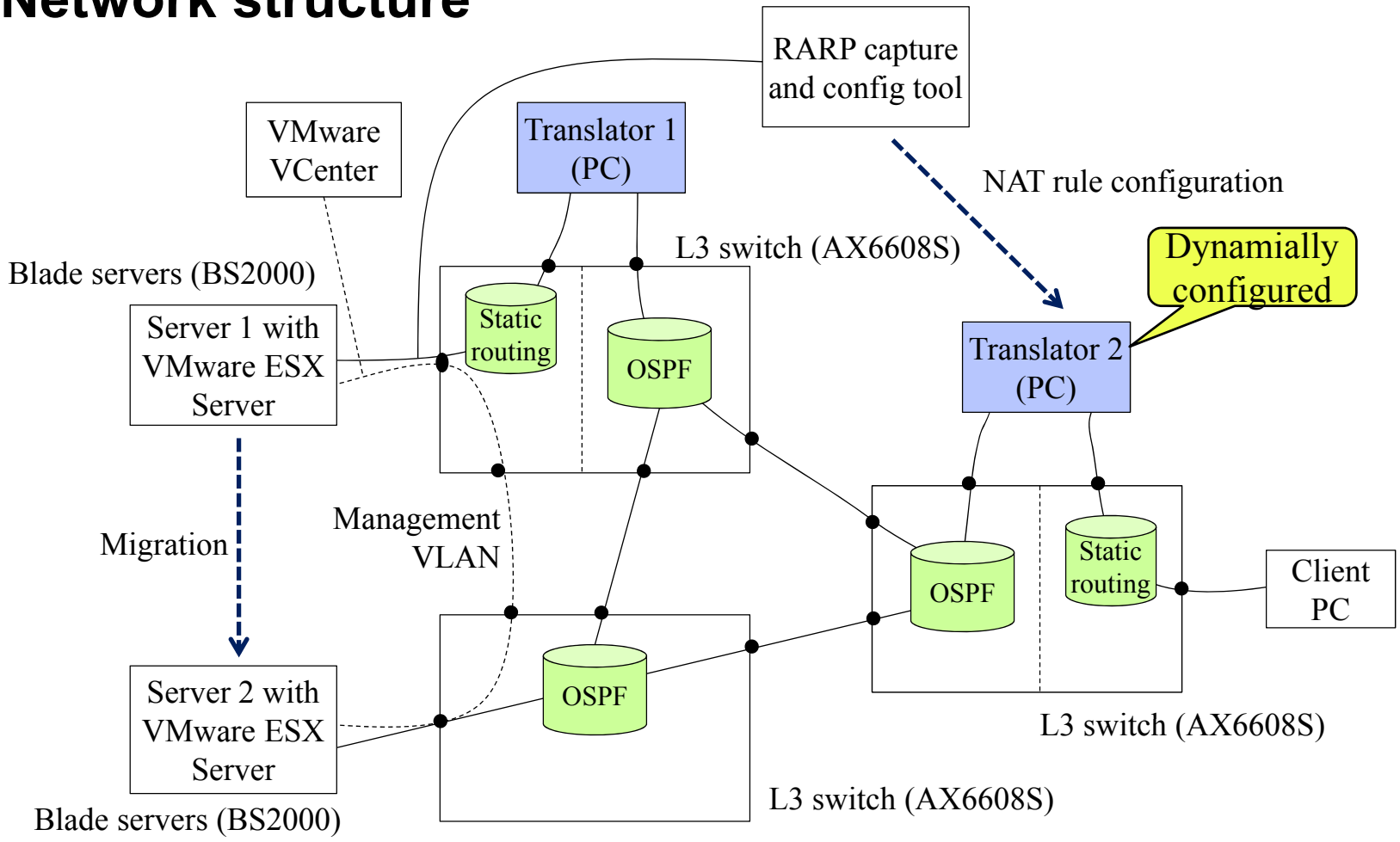



After migration



# Application To VM Migration (cont'd)

## ■ Network structure




## ■ The VNs worked in an expected way.

# Conclusion and Future Work

## Summary and conclusion

- Two network virtualization (NV) architectures were described and compared: Network paging and network segmentation.
- Network-paging-based (ATV) method was investigated.
  - Intranet- and extranet-type communication methods based on this architecture were proposed.
- ATV has several advantages compared to segmentation:
  - less packet overhead
  - flexible page size
  - page-by-page processing
- Network paging is a promising NV architecture.

## Future work

- To develop and evaluate ATV-based methods and networks.