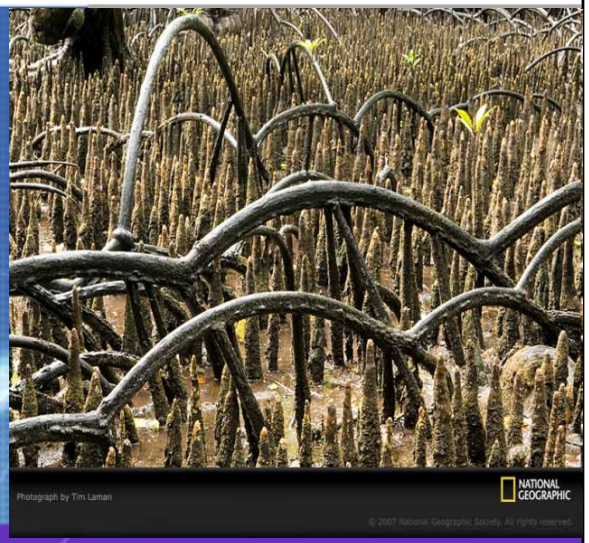
Next-Gen Virtual Networking



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Next-Gen Network Virtualization -- Summary

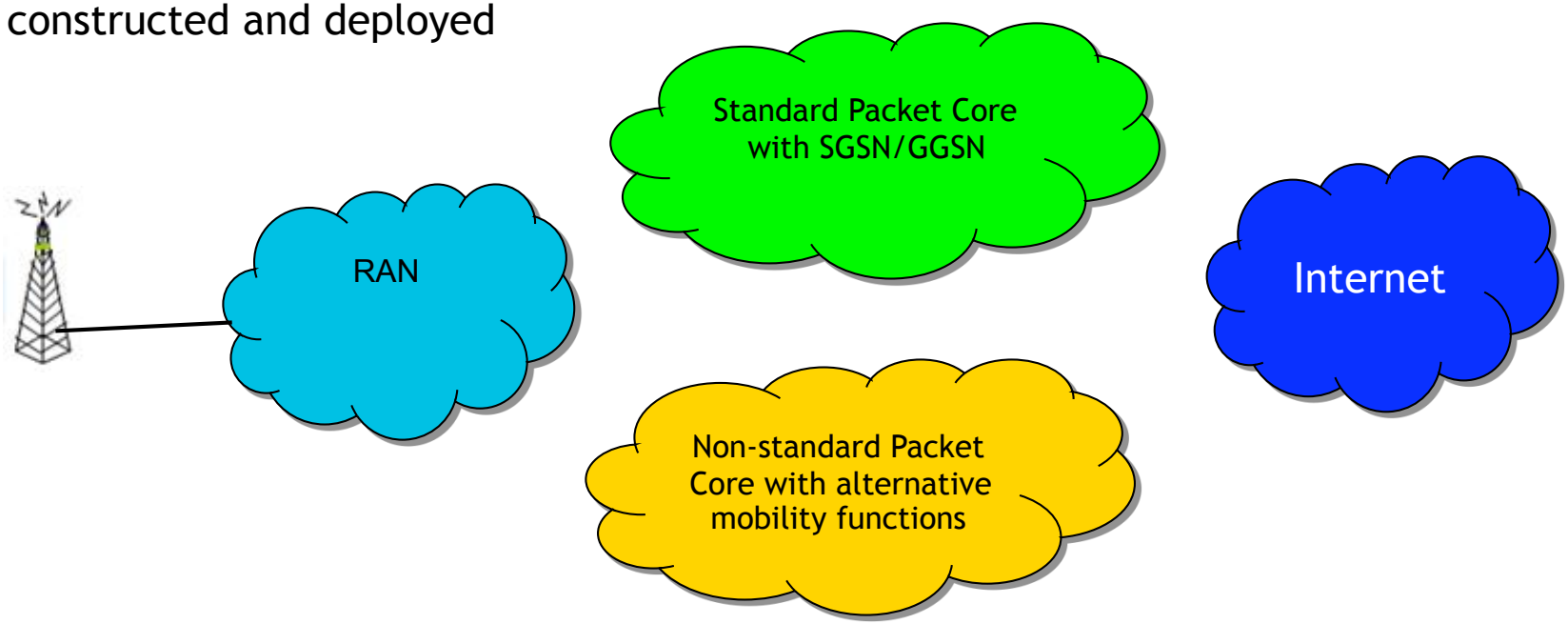
- There are two technology streams—VPNs and server virtualization/cloud computing — influencing network virtualization.
- Many new applications require integration of these two technologies and greater support from the network for their specific needs.
- VPNs will be tied much more closely with content distribution and virtual computing.
- Our approach – NG Virtual Networking: Create a system which allows a user (such as an enterprise and virtual telco) to set up a combination of computing and networking resources based on a high-level specification.
- Innovations needed: A new language for specifying application needs, algorithms for provisioning, a virtualized router with an architecture to run multiple protocol stacks in parallel and with flexible packet pipelines, and a software foundation.

Use Case 1: Alternative Network Architecture for Lower Cost/Higher Performance

Some service providers are willing to adopt non-standard/alternative architectures/procedures/techniques if substantial cost benefits can be realized

Example:

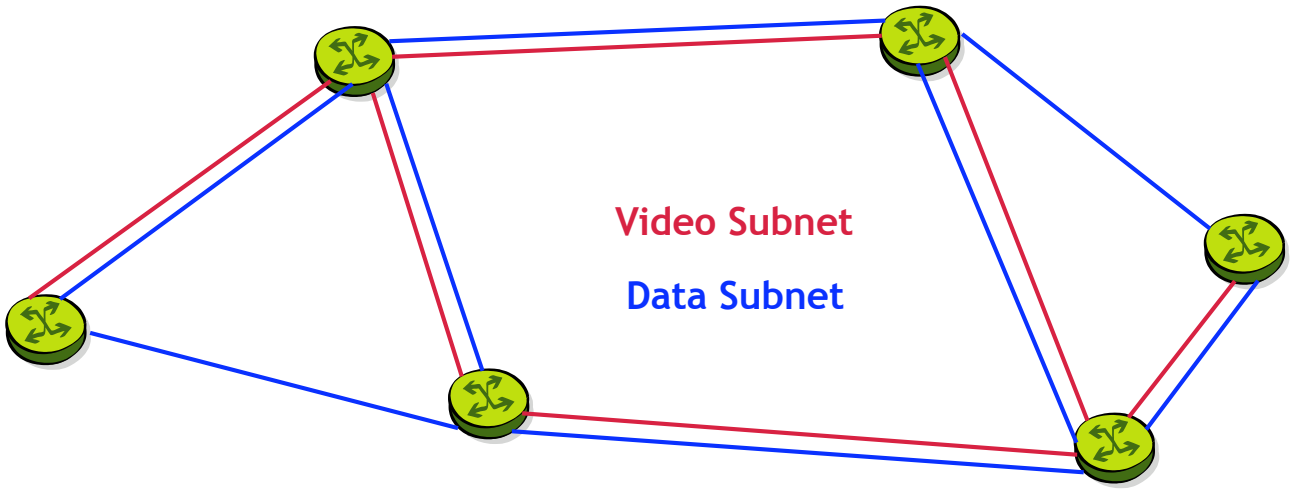
- Mobile service providers' job is to get packets to/from mobile from/to Internet
- Alternative models to current mobile core (PDSN/HA, SGSN/GGSN, SGW/PGW) can be constructed and deployed



Use Case 2: Alternative Network Architecture for Lower Cost/Higher Performance (cont'd)

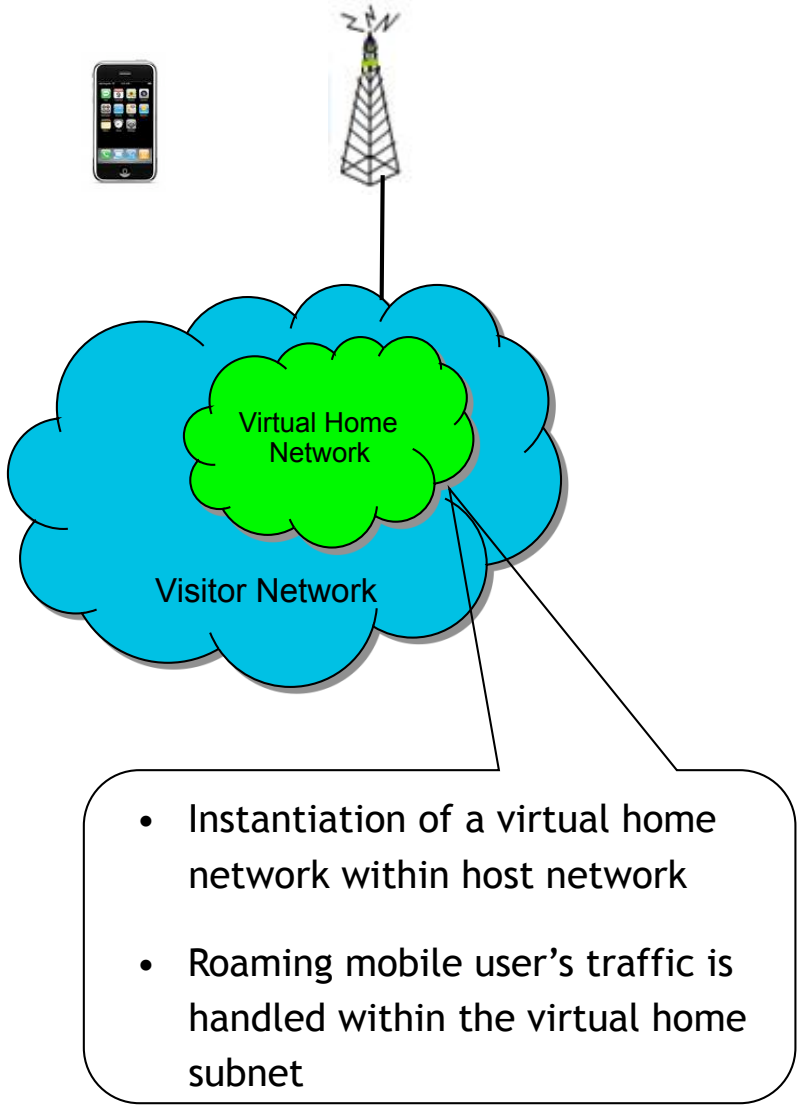
Video-only Network:

- Construction of a video transport network with different protocols can yield substantial cost savings and operational efficiency
- Transport of video over IP is far from optimized
  - ➢Small packet size
  - ➢Lack of useful video feature – one-way broadcast



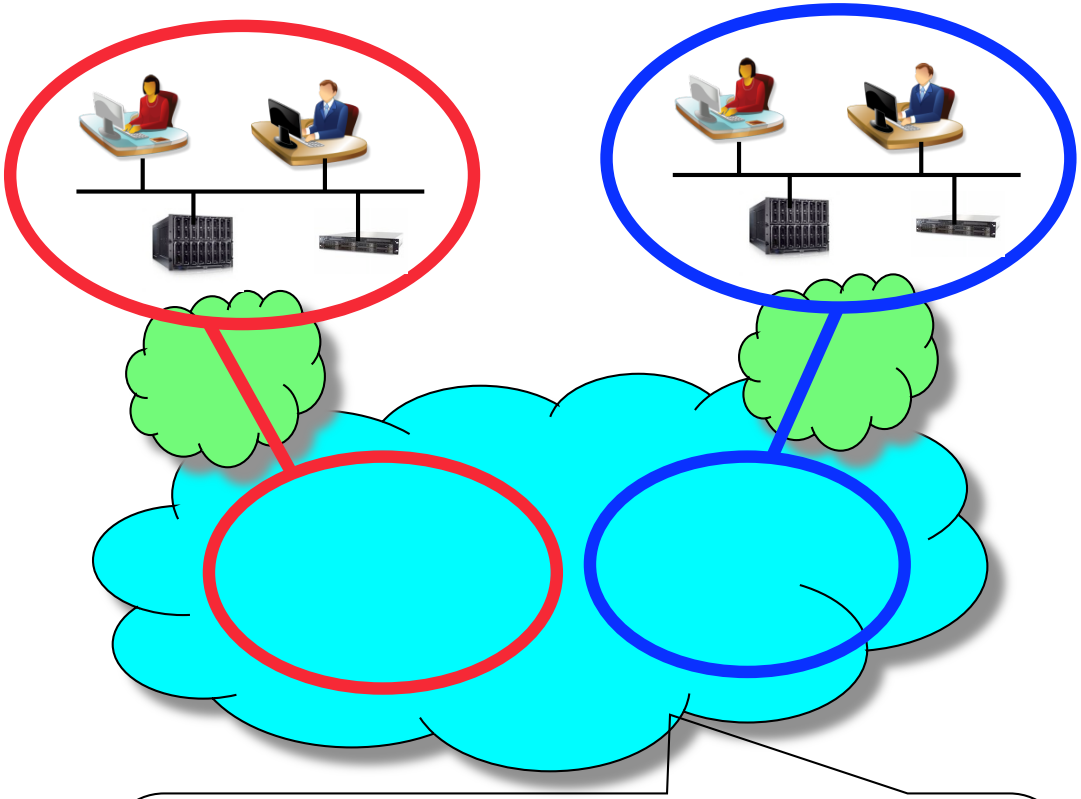
Use Case 3: Virtual Hosting of "Foreign" Functions

- Example: Mobile Roaming
  - Instead of "backhauling" roaming traffic home and getting services, instantiate a virtual copy of "home" in a visitor network
- Benefits:
  - Savings in backhaul
  - Performance improvement such as reduction in latency
- Issues:
  - Legal intercept – enforcing home country's law in a foreign operation



Use Case 4: Virtual Private Cloud in Shared Data Center

- Example: Enterprise Cloud Computing
  - An enterprise may tap cloud resources to augment its internal resources. Cloud resources along with a VPN are set up in a way that they reside within its security boundary.
- Benefits:
  - Lower capital cost – enterprise needs only build infrastructure for average demand
  - Instant scalability – cloud resources can be allocated and de-allocated in short time scale



- Shared data center where cloud resources for enterprises are allocated.
- Each virtual private cloud is isolated from each other, but “attached” to their respective enterprise network

Common Concepts Among all Use Cases

- Virtualization of all resources such as links, routers, and servers should be done.
- All resources for computation, storage and networking should provide their slices as units of allocation
- Dynamic allocation/release of these resources in short time scale should be enabled
- The solution should have high scalability with rapidly redeployable resources

NG Virtual Networking
Creating a combined network and compute system

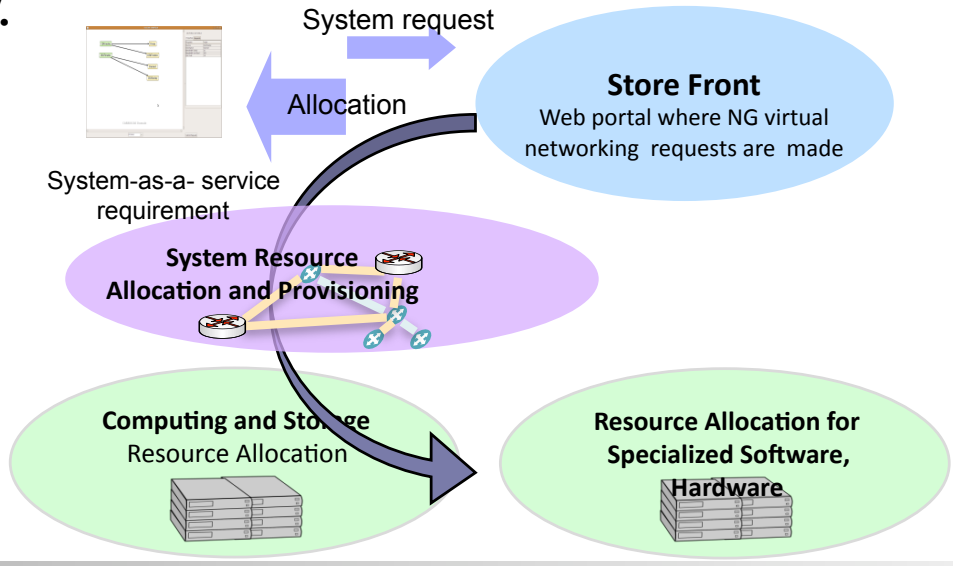
- Infrastructure adapts to different apps by choosing appropriate protocol stack(s).
- An enterprise or virtual telco specifies networking and computing requirements in a specification language.
  - The service provider gets requests to set up different networking & computing infrastructure on demand.
  - Each set-up request specifies connectivity, policies, bandwidth, and computing needs etc.
- Dynamic provisioning system carves out a virtual network and computing resources from the underlying physical network and computing cloud based on these specs.
- As number of the application users grows, additional resource assigned dynamically.

Issues:

How do we virtualize a networking substrate?

How does one manage a virtual network?

How does one create a dynamic networking solution?



Key Elements for Realizing This Vision

I. A language for specifying networking and computing needs.

II. Algorithms for optimally allocating resources in the network and the computing cloud for deployment of a distributed application.

III. A virtualized router which provides finer level of granularity in multiple dimensions such as relative delays for different clients in gaming networks.

IV. A software foundation that enables building and deployment of distributed applications in data centers and networks.

I - Language: An Example Resource Request

A customer requests all needed components for deploying a new application in an XML-based language.

Information in a request

- Network connectivity requirement
- Computing needs
- Storage needs for caching and content
- Needs for special-purpose processing
  - Transcoders, DSP, and echo-cancellers
  - Software-as-a-service applications

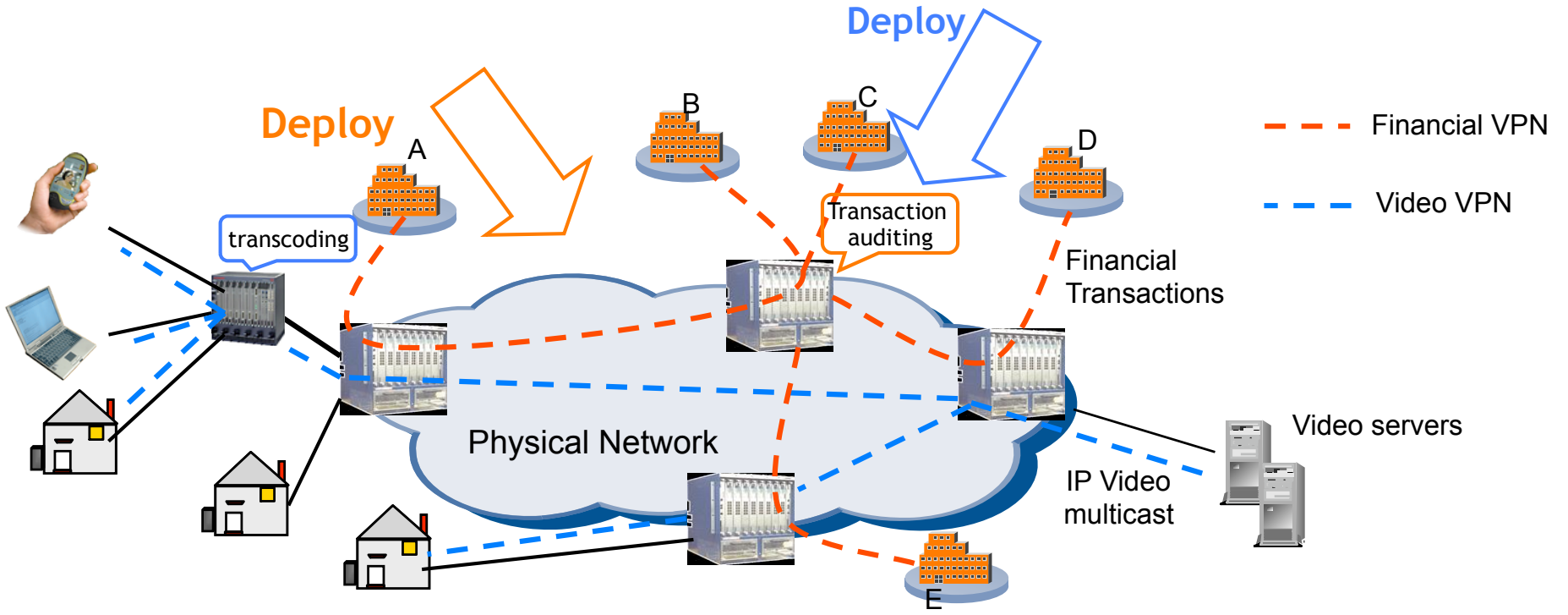
Language Example: Financial / Video connectivity Services

Financial connectivity:

- Traffic matrix: A->C: 10Mbps, B->D: 20Mbps, …
- High security, isolation from other traffic
- Very low latency
- Value-added service: transaction auditing, …

Video connectivity:

- Traffic demand: video server location & capacity, receiver location & capacity, …
- QoS guaranteed session creation
- Multicast capable, NACK control
- Value-added service: transcoding



Language Example: Financial Connectivity

```
<network>
   <site>
      <name>NY</name>
      <ip>135d.3.98.0/24</ip>dd
      <bandwidth>10Mbps</bandwidth>
   </site>
   <site>
      <name>WashingtonDC</name>
      <ip>124.7.50.0/24</ip>
      <bandwidth>10Mbps</bandwidth>
   </site>
   <routing>unicast</routing>
   <delay>5ms</delay>
 </network>
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<service>
   <type>TransactionAudit</type>
   <location>any</location>
   <list>
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         <from>135.3.98.0/24</from>
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</service>
```

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   </VMGroup>
</computing>
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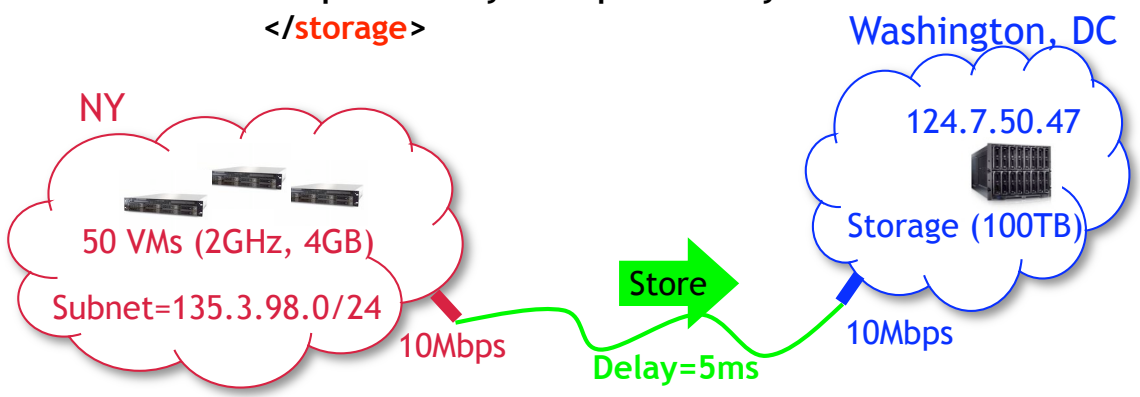
   <security>high</security>
   <prefVicinity>NY</prefVicinity>
</storage>
```



II - Algorithms for Resource Allocation

- The provisioning system must allocate resources for demands. Here are the resources:
  - Computing, storage and specialized hardware (transcoding) capability
  - Connectivity with service-level guarantees
- Requests arrive one at a time (not all at once). This means that the algorithms have to be on-line.
- Allocation algorithms must satisfy as many requests as possible
- Specific variants need to be developed for application-specific services

Algorithmic Challenges for Gaming

An on-demand gaming application

A group wants to set up a gaming session on-demand from different points of attachments into the network

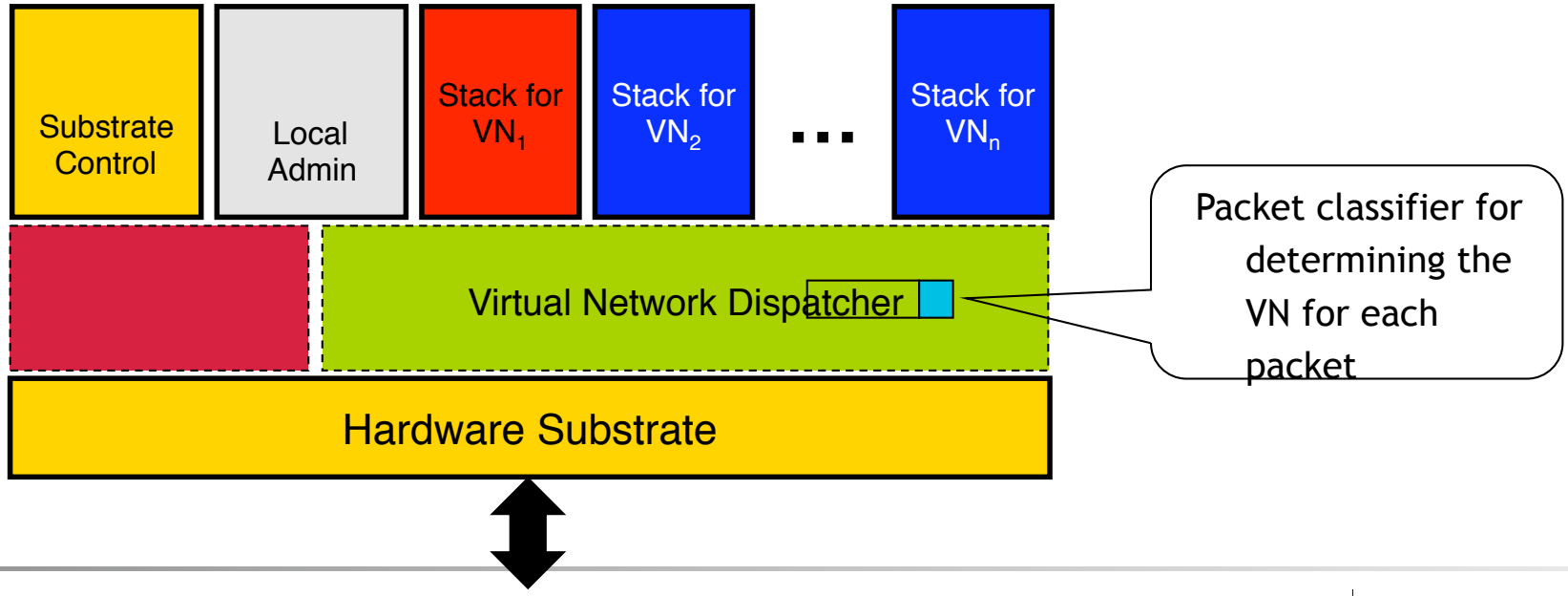
- Request specifies network service needs, game service, server need
- Games may have special SLA needs – ex: minimize difference in delays between servers and endpoints. Impacts server placement, path selection
- The provider sets up a “virtual private network” for the group on demand
- A SLA with the constraints of equal delay for a dynamic user population must be provided.

III - Virtualized Router: Multiple Protocol Stacks

- Each virtual network can implement its own protocol stack that is optimized for its purpose.

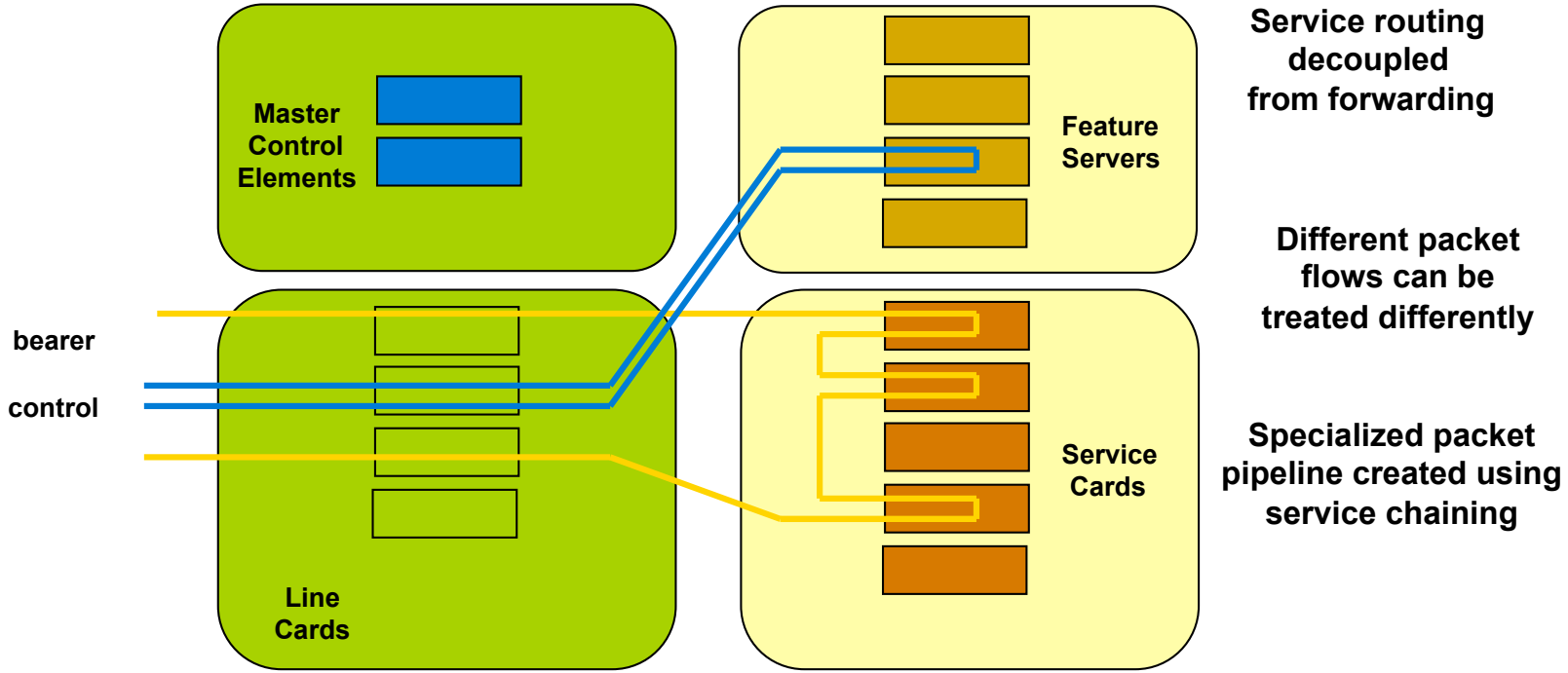
  Examples:

  - A video virtual network may use a transport other than IP/RTP that allows for larger packet size
  - A gaming virtual network may use least latency routing, rather than shortest hop routing.
  - A virtual network dedicated to content may use the content-centric networking protocol as proposed by Van Jacobson



Protocol Pipelines & Interconnection Fabrics

- Specialized packet processing engines have to be designed for non-IP protocols.
- Even for IP packets, new scheduling procedures need to be designed.
- Transferring packets with different formats and lengths will require some changes in router interconnection fabrics.



IV - Software Foundation

- The software foundation is a common software layer in all elements – networking and computing – to create a cohesive system which can be provisioned jointly.
- It runs on routers, virtual computers in data centers and "micro clouds".
  - Data centers can be sourced from multiple providers, yet the software foundation makes them look as one.
  - Micro clouds are computers kept adjacent to or inside routers that help control the virtual network
- The software foundation further provides the necessary hooks to monitor the health of the application and the network, and …

  … compares measurements with application-specific service-level agreements (SLAs). It can make the computing, storage and network adjustments to deliver the SLA.

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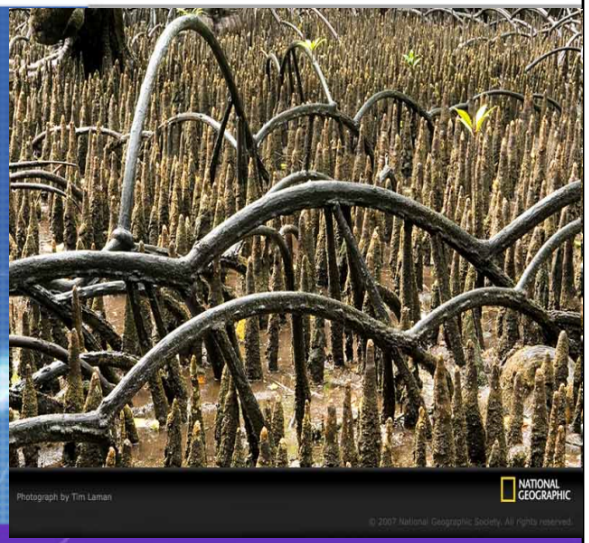

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