

Challenges in Resource Allocation in Network Virtualization

By

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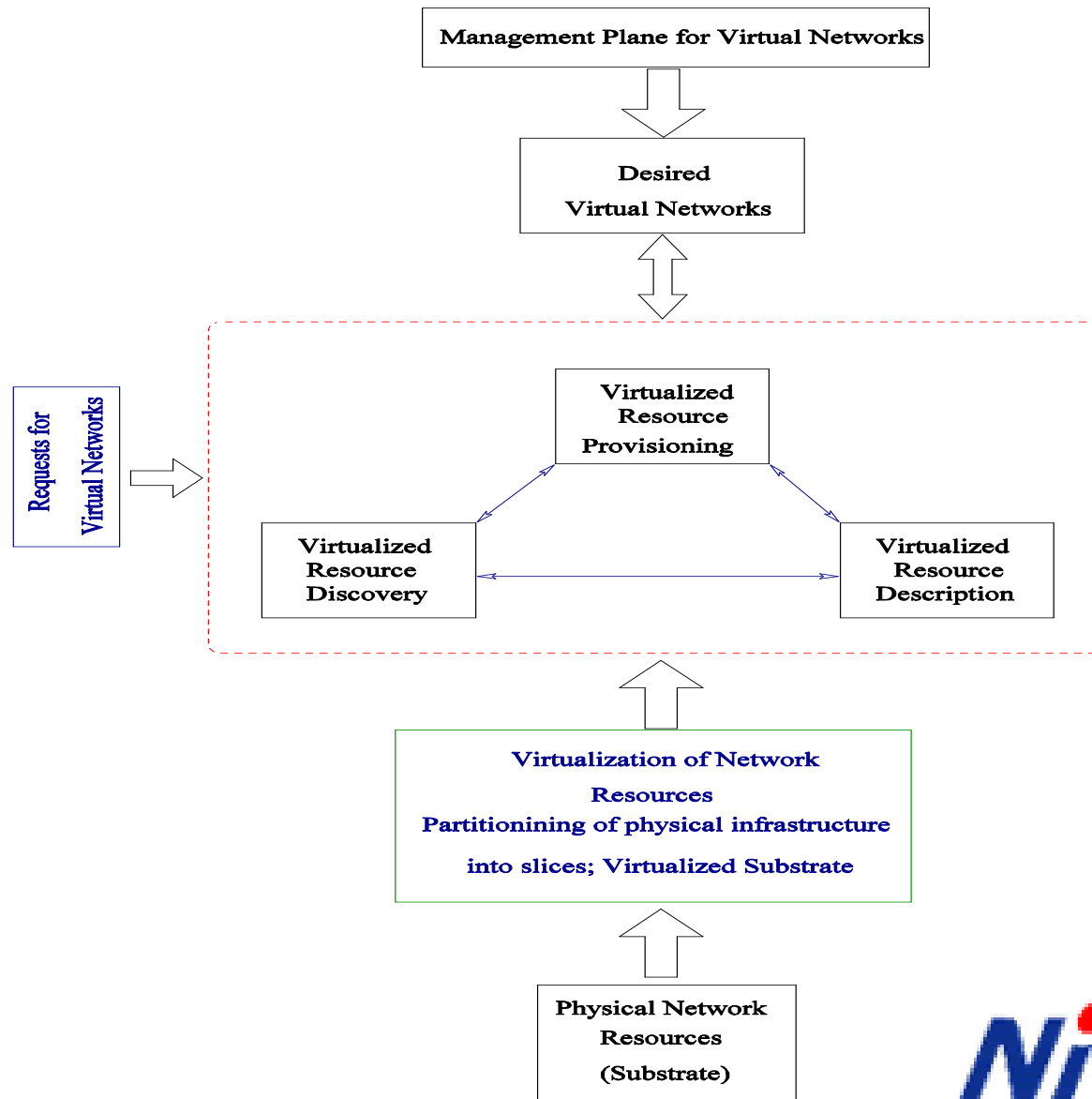
Outline of Talk

- Some basic principles for instantiation of Virtual Networks (VNs).
- Problem description
 - VN assignment as NP-hard problem
- Approaches to resource allocation in VNs
 - Static Approaches.
 - Dynamic Approaches.
 - Miscellaneous Approaches
- Implementation of Resource Management
 - Resource Allocation in VN-testbeds.
 - Summary of major challenges
- Concluding remarks

Basic Principles:

- Three intertwined processes:
 - Resource description, Resource Discovery and Resource Provisioning
- Some important goals for future policy driven resource management systems for VNs:
 - System must allow for reservation of resources for a predictable operation
 - System must provide enough isolation
 - An admission control mechanism is essential

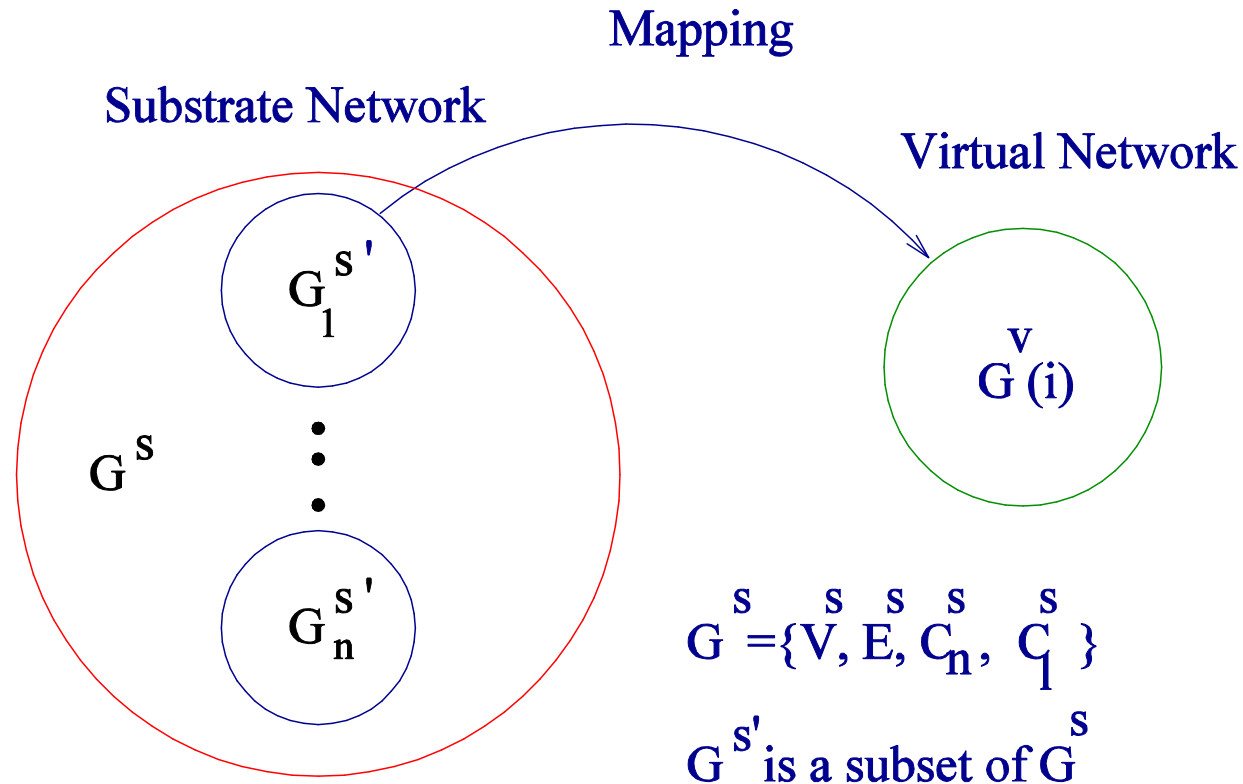
Steps involved in instantiating VNs



A brief description of problem

- VN embedding is NP hard problem.
 - Assigning VN nodes to SN without violating capacity constraints is reducible to multi-way separator problem which has been shown to be NP-hard in the literature, [12].
 - Possible solutions: brute force, simulated annealing, sparse cuts or multi-commodity flow approaches.
- One way to reduce the overall complexity is to divide VN embedding problem into node and link assignment sub-problems.

Problem description... (contd.)



$$G^s = \{V^s, E^s, C_n^s, C_1^s\}$$

$G^{s'}$ is a subset of G^s

$$G^v(i) \rightarrow \{V, E, C^{s'}, C^{s'}\}$$

VN embedding can be decomposed as:
Node assignment and Link assignment

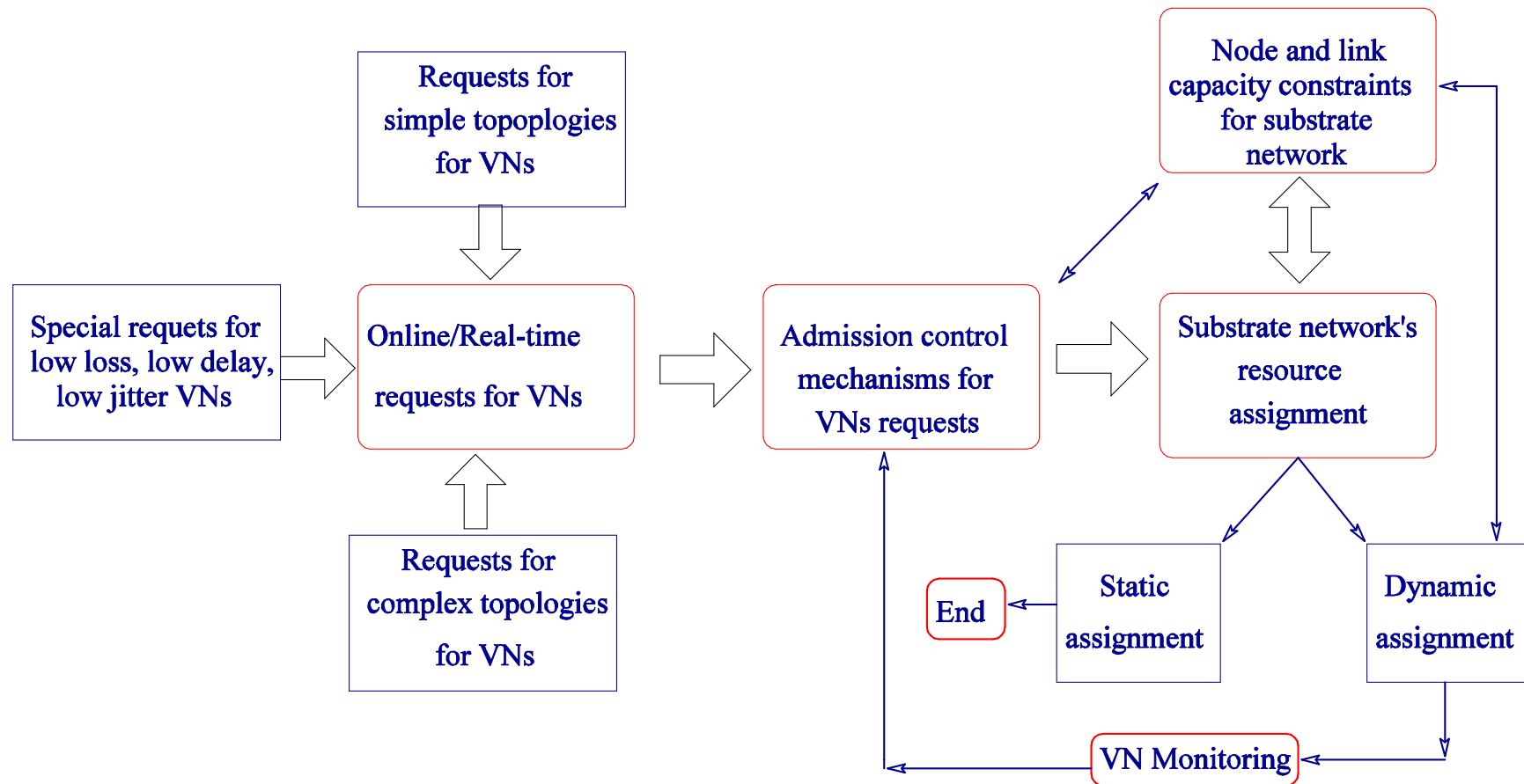
Role of Objective Functions

- Current approaches:
 - Minimize Node and Link stress.
 - Maximize the Revenue of provider.
 - An important issue is correct definition of Revenue (CPU usage, Memory Usage, Bandwidth)
- Our approach is to define revenue in terms of some average values of CPU, Memory and BW usage. Time series analysis of CPU and Memory usage data from CoMON data. <http://comon.cs.princeton.edu/>
- Also to introduce service/architectural resiliency factors in VNs.

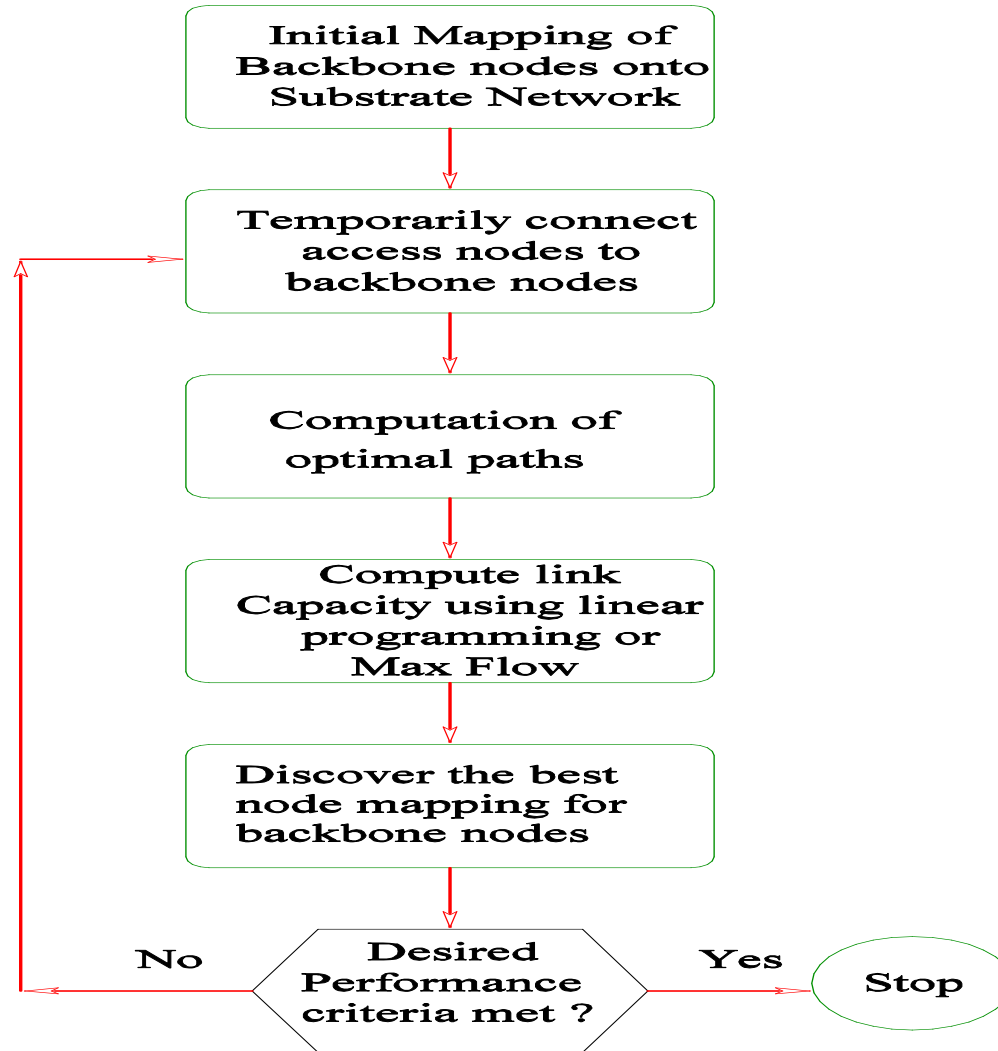
Approaches to VN Embedding

- Static approach: does not allow changes in resource assignment during life time of a VN.
- Dynamic approach: allows to adaptively change the resource assignments on the basis of current demands and performance of VN. It requires a constant monitoring of VN as well as dynamic updating of node and capacities.
- Misc: Autonomic systems based [34, 35] and Control theoretic based.

A conceptual view of static and dynamic approaches for VNs



An example of static approach

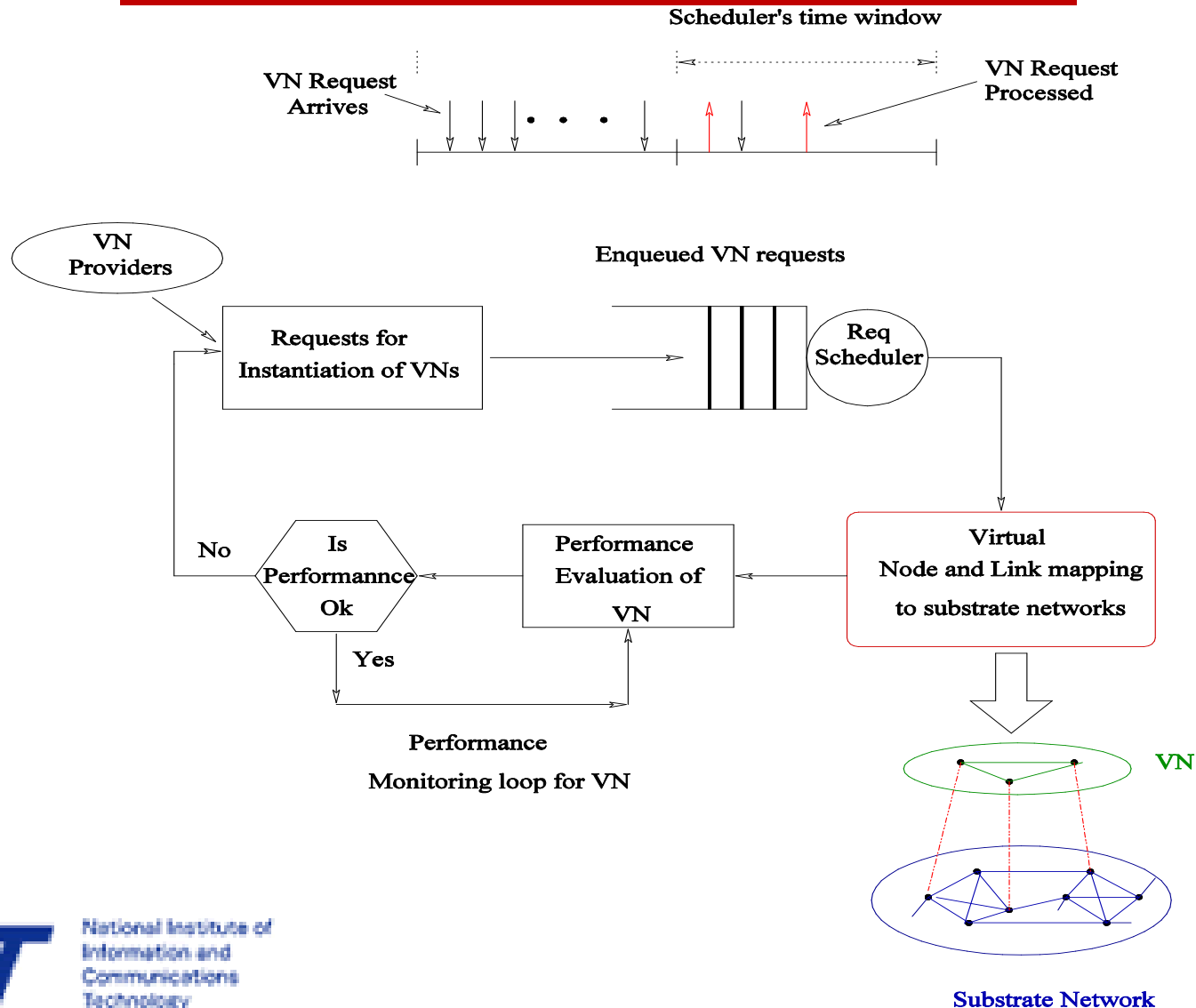


Iterative Method for Resource Assignment in VNs [27].

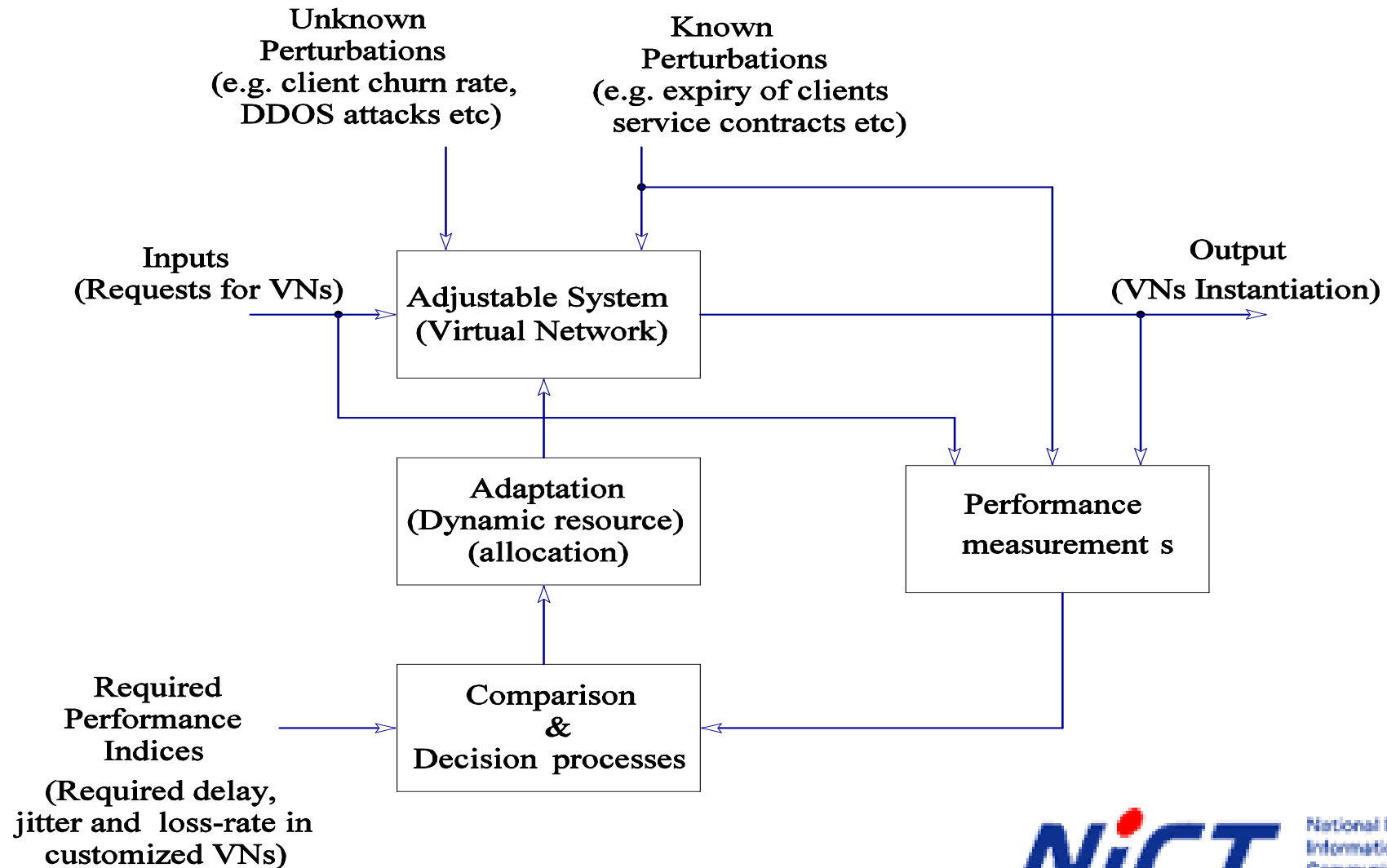
Dynamic Approaches

- Completely dynamic approach very difficult to design, due to NP hard nature of the problem.
 - Recently an attempt has been made: DaVinci: Dynamically Adaptive Virtual Networks for a Customized Internet, Dec. 2008, [33].
 - However, it only considers the bandwidth allocation and node allocation has been skipped.
- Another possibility is to use the market based designs such as Bellagio, share etc. However, compared to scheduling based approach, the reservation of resources is harder.

A System-theoretic model for resource allocation process in VNs



An Adaptive Control Systems for VNs



A brief outlook on resource allocation in VN- testbeds

- Planetlab
 - Users select their own nodes for experiments on ad-hoc basis. A recent study has shown that status of nodes change in 20 ~ 30 mins.
 - Monitoring services such as Ganglia are available to PlanetLab users. Also resource discovery mechanism such as SWORD are available. But use of this information is not compulsory.
 - Similarly CoSTAT and CoMON are used to gather data about various nodes and links (CPU, Memory and BW).

A brief on resource allocation in VN- testbeds ...(contd)

- Emulab uses assign facility for node allocation. It has been based on simulated annealing mechanism. However, for dense topologies, its performance is quite slow. Thus, coarsening algorithms are being suggested.
- In GENI resources are being allocated by Slice-Embedding Service by using RSpec. For further details please see literature.

Five Major Challenges for Network Virtualization

- A comparative study of various existing theoretical approaches for cuts in graphs of VN and substrate networks. Thus, development of efficient heuristics . Transforming heuristics for static to dynamic scenario is an open problem.
- Designing traffic adaptive techniques for resource allocation in VNs. Initial allocations can be made on the basis of long term behaviour of traffic. Later on it will be required to adapt to shorter time scales. A study of trade-offs among stability, optimality, signalling overheads, hardware limitations and resiliency is crucial.

Challenges...(contd.)

- Application of principles of adaptive feedback control theory/game theory to heuristics for resource allocation in VNs. Also investigating the possibility of application of autonomic computing techniques for VNs.
- Fulfilling the major requirements for resource discovery and allocation (synchronous, QoS enabled, guaranteed services, incentives and consolidation of resource discovery and allocation)

Challenges...(contd)

- Managing trust among the global users of VN test beds will be an important research issue. Currently, a federation of major test-beds through a unified interface for global authentication is under development. A correct balance is desired between centralized and decentralized architectural extremes.

Concluding remarks

- Resource allocations is a fundamental activity in instantiation of VNs.
- Dynamical approaches for resource allocation are difficult to design. However, semi-dynamic techniques are possible by adopting path migration, splitting and splicing in substrate network topology.
- Overall complexity of resource allocation can be reduced by decomposing into node and link assignment problems.

Concluding remarks...(contd)

- Solving these two problems in sequential manner may not yield satisfactory results. Thus, intelligent heuristic are required to solve these two sub-problems simultaneously.
- Autonomic computing techniques are promising but they are well developed yet for VN resource assignments.
- Lessons learned from VN-test-beds, such as Emulab, PlanetLab and GENI can also be very useful for designing resource allocation methodologies.

Thank you everybody

Questions ??