



# Virtual Network Embedding in Federated Virtualized Platforms

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FIRE research workshop, Budapest, 16 May 2011



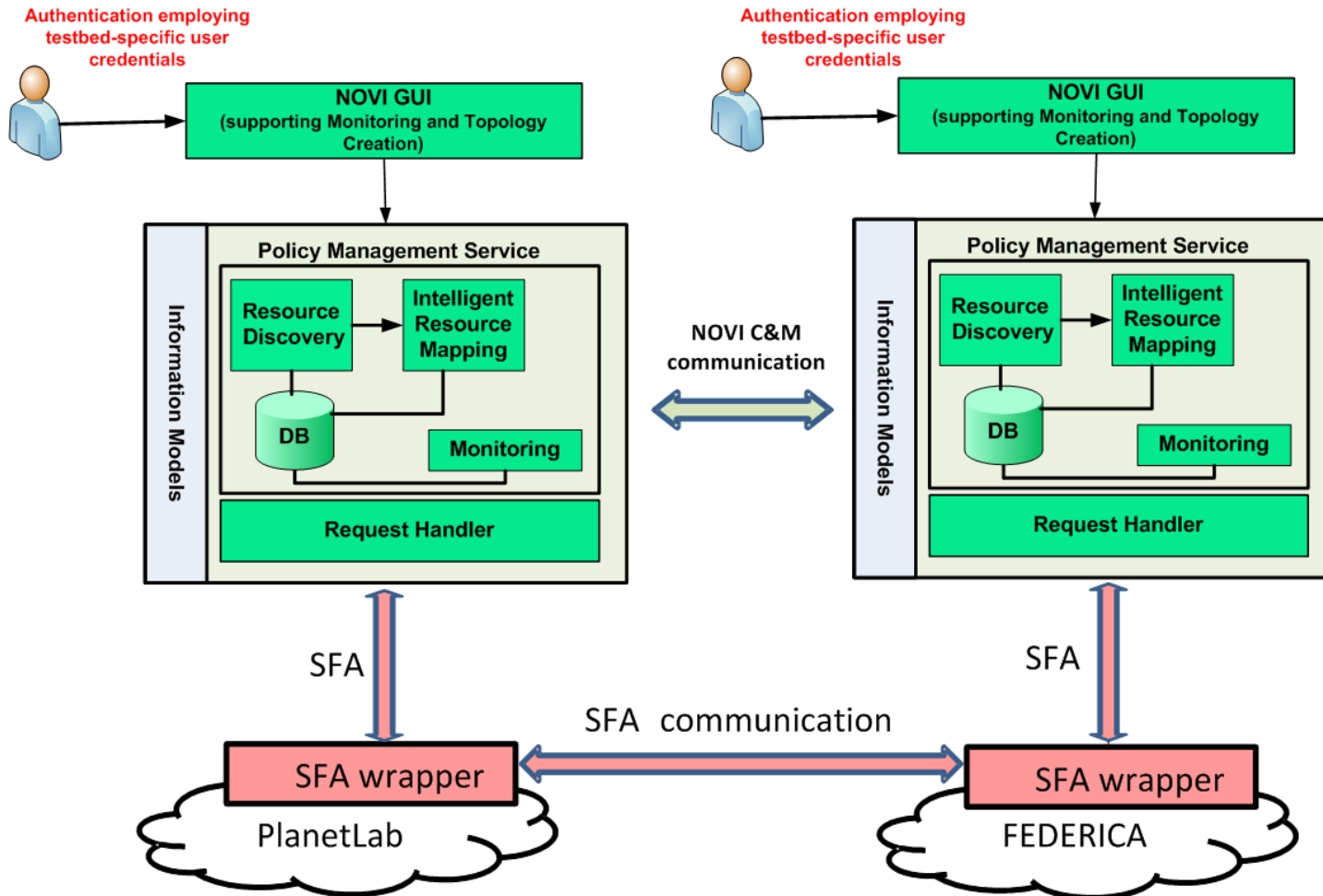
# Networking innovations Over Virtualized Infrastructures



- ✓ NOVI concentrates on methods, algorithms and information systems that will enable users to compose and manage isolated slices, baskets of virtual resources and services provided by diverse yet federated Future Internet (FI) platforms.
- ✓ NOVI's goal is to primarily address the issue of vertical federation by designing and prototyping a service portfolio based on combined virtualized facilities from the FEDERICA and PlanetLab Europe virtualized infrastructures.



# NOVI's architectural view





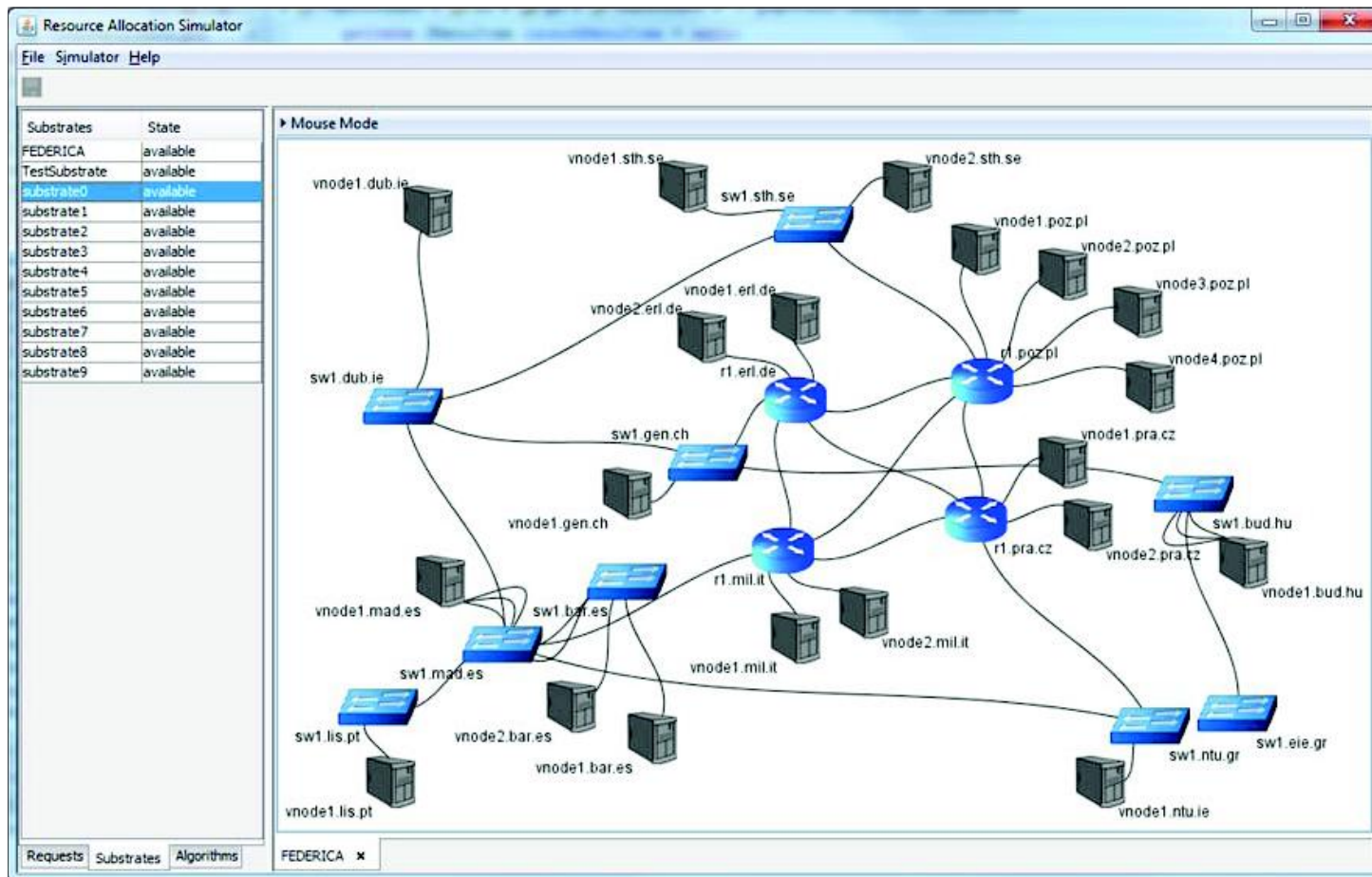
# NOVI'S Intelligent Resource Mapping Service



- ❑ Intelligent Resource Mapping Service:
  - Supports embedding user requests for **virtual resources** nested within a federated **shared physical substrate**.
  - Virtual Network Embedding Problem (NP-hard multi-way separator problem)
  
- ❑ Efficient allocation and scheduling of physical resources to multiple slices:
  - Maximizes the number of coexisting overlays
  - Enables efficient load balancing
  - Increases the utilization of substrate infrastructures



# Virtual Network Embedding (1)





# Virtual Network Embedding (2)



Resource Allocation Simulator

File Simulator Help

Requ...	Start	End	State
gra23R...	0	12	available
reques...	30	1030	available
reques...	15	1015	available
reques...	22	1022	ready
reques...	33	1033	available
reques...	22	1022	available
reques...	27	1027	available

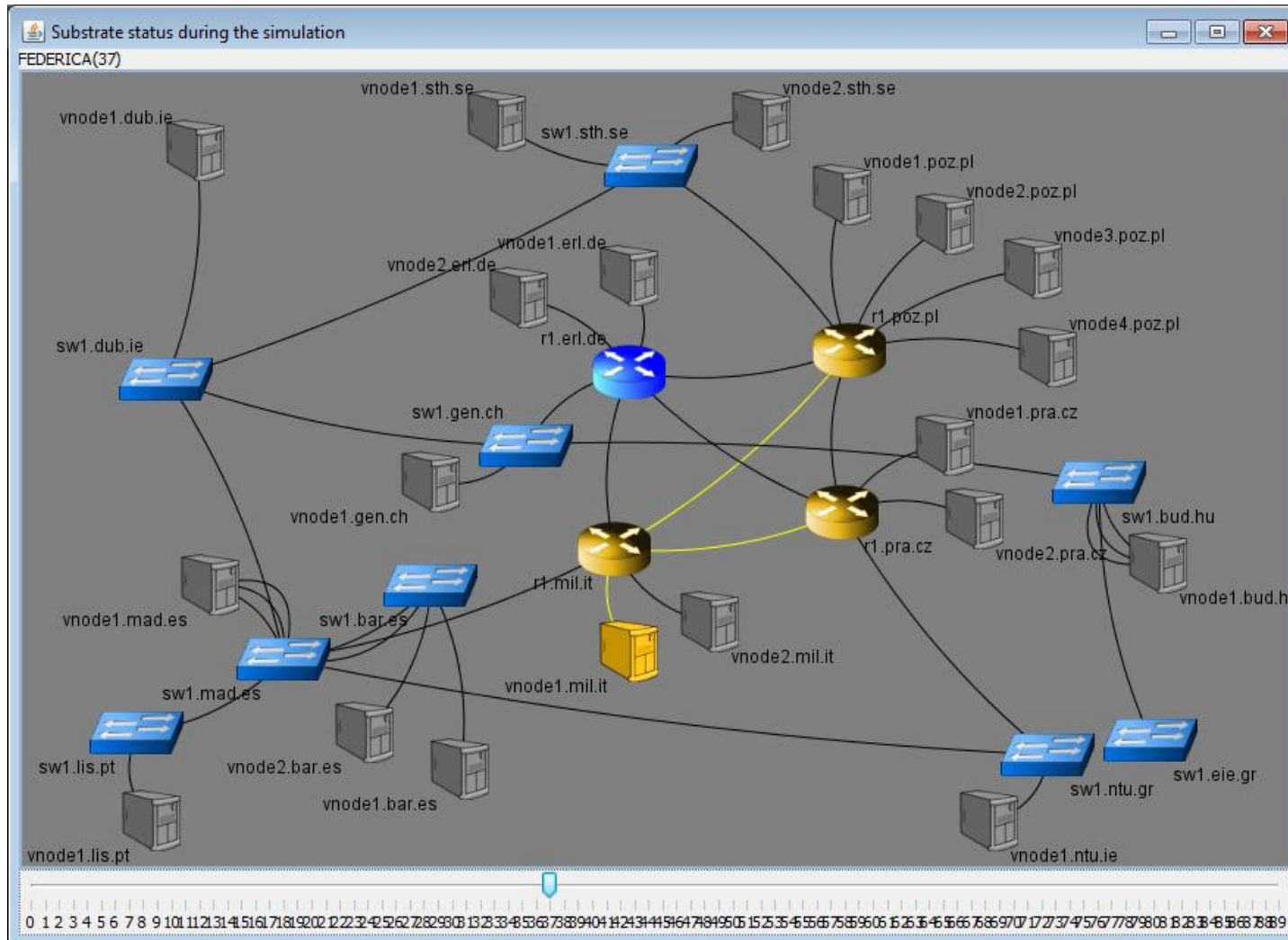
Mouse Mode

Requests Substrates Algorithms

requests0 x requests1 x requests2 x requests3 x



# Virtual Network Embedding (3)





# Virtual Network Embedding (4)



- Various alternatives for solving the mapping problem:
  - Requests concerning individual resources (VMs, logical routers/switches) may lead to the adoption of a greedy node mapping algorithm
  - Requests for baskets of resources – slices – require solving the full VNE problem via appropriate heuristic algorithms.



# Intelligent Resource Mapping Service



- NOVI's Intelligent Resource Mapping Service Requirements:
  - ✓ Respect the limitations of physical resources.
  - ✓ Meet hard and soft Quality of Service requirements.
  - ✓ End-to-end QoS vs. per (bottleneck?) node basis
  - ✓ Near real-time handling, possibly in a way depending on the usage policy, the lifetime of a request etc.
  - ✓ Intelligent and efficient allocation, scheduling and migration of resources in federated, heterogeneous environments.
  - ✓ Partial access to state information – abstracted views across domains.



# Virtual Resource Mapping in NOVI



Devise new and apply existing heuristics on a layer 2/3 network topology including heterogeneous network infrastructure [1]



Create an emulation environment to assess multi - domain virtual network embedding algorithms and tune them to fit anticipated user/operator requirements



# Emulation Environment



## □ Technical information

- Java-based simulator.
- JUNG [2] library for the manipulation, analysis, and visualization of data that can be represented as a graph or network.
  - Wide variety of representations of entities and their relations
  - Implementation of algorithms theory
  - Very versatile visualization framework
- GUI: JFC (Swing/AWT) framework [3].
- CPLEX [4] has been used to solve the relaxed MIP problem.



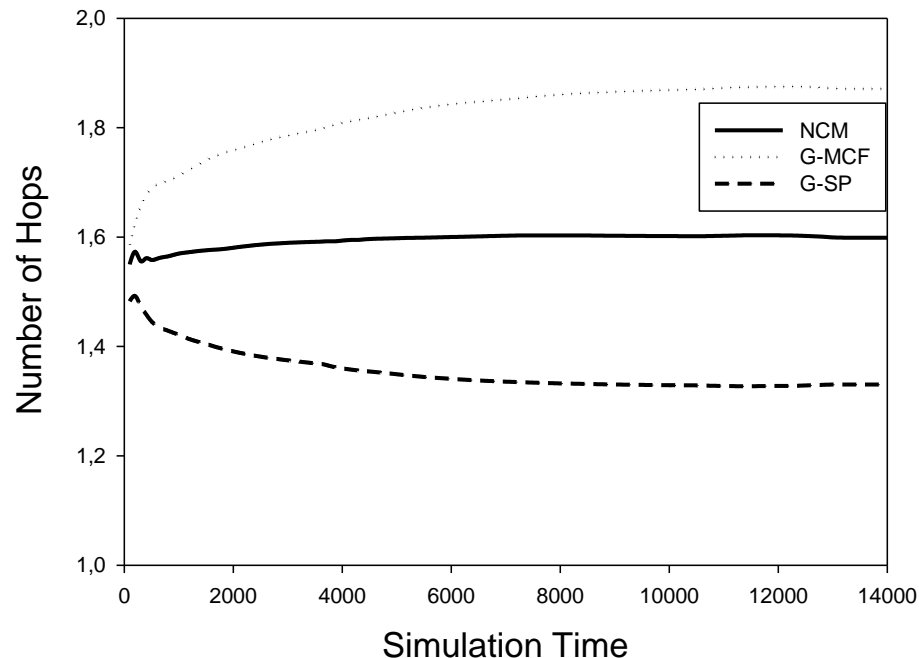
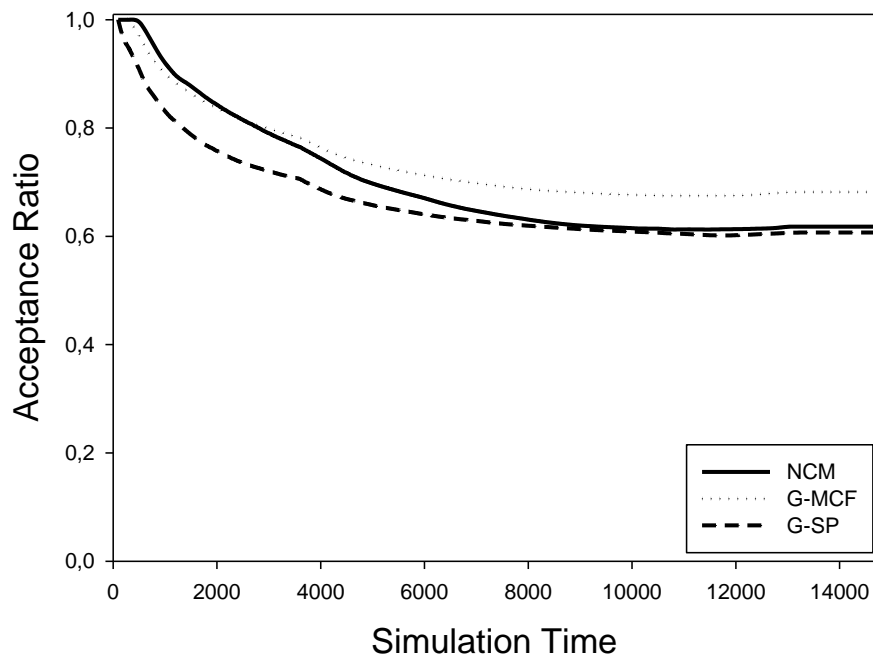
# Adopted online VNE approaches



Approach\Mapping Phase	Node Mapping	Link Mapping
G-SP [5]	Greedy Node Mapping	Shortest Path Algorithm
G-MCF [6]	Greedy Node Mapping	Multi commodity flow problem
NCM [1]	MIP formulation of VNE (LP relaxation, randomized rounding technique)[7]	<ol style="list-style-type: none"><li>1. Multi commodity flow problem</li><li>2. Shortest Path Algorithm</li></ol>



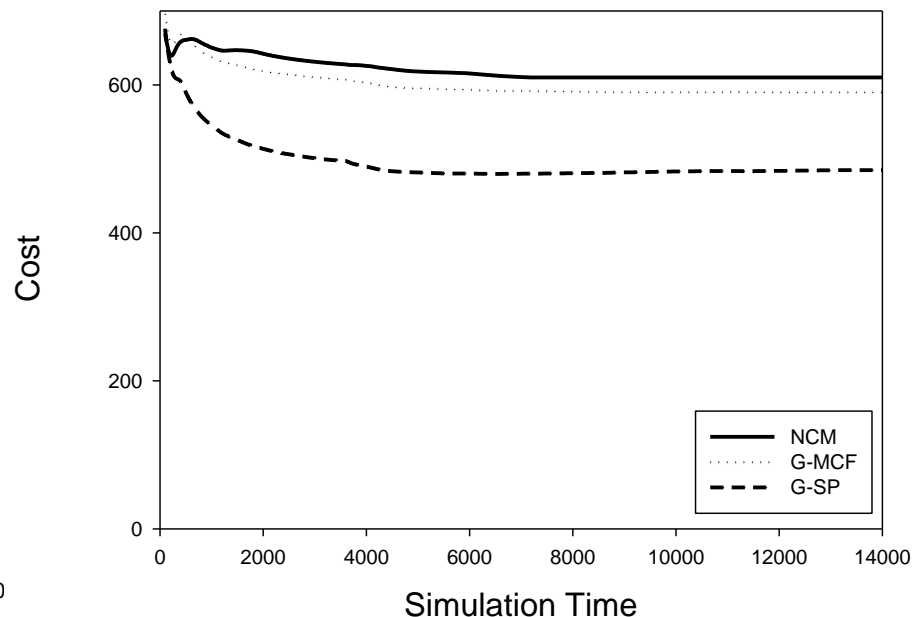
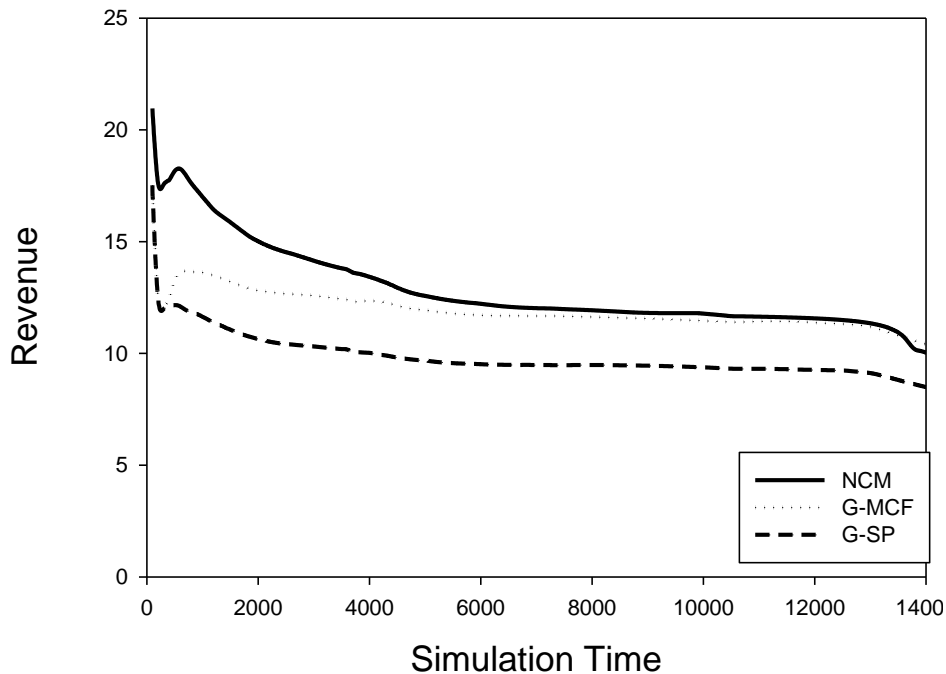
# Results: Evaluation and comparison



- ✓ NCM provides a trade off between G-SP and G-MCF in terms of acceptance ratio of mapping requests and number of substrate hops per virtual link.



# Results: Evaluation and comparison



- ✓ NCM manages to embed requests that generate more revenue, at a cost similar to G-MCF.



## Future work



- ✓ NCM enhancements and additional heuristics on solving the VNE based on different constraints.
- ✓ Resource discovery (e.g. based on functional attributes)
- ✓ Appropriate resource grouping on NOVI repositories to facilitate fast resource matching



# References



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- [2]. JUNG 2.0.1, <http://jung.sourceforge.net>.
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- [7]. M. Chowdhury, N.M. Raihan Rahman, R. Boutaba, “Virtual network embedding with coordinated node and link mapping,” IEEE INFOCOM’09, pp. 783–791, Apr. 2009, doi:10.1109/INFCOM.2009.5061987.