The Dynamic Placement of Virtual Network Functions

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May 2014

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- The focus here is the dynamic management and orchestration of virtual networks (VNs), with particular attention paid to placement of these virtual resources. The physical resources will be shared by multiple virtual networks which are independent of each other and are allocated to different customers of the network.

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- The orchestrater manages the creation and removal of the virtual nodes, as well as configuring, monitoring, running and stopping software on them.
- As a proof of these concepts, a distributed orchestrater prototype has been designed, implemented and tested with the results of different placement algorithms presented.

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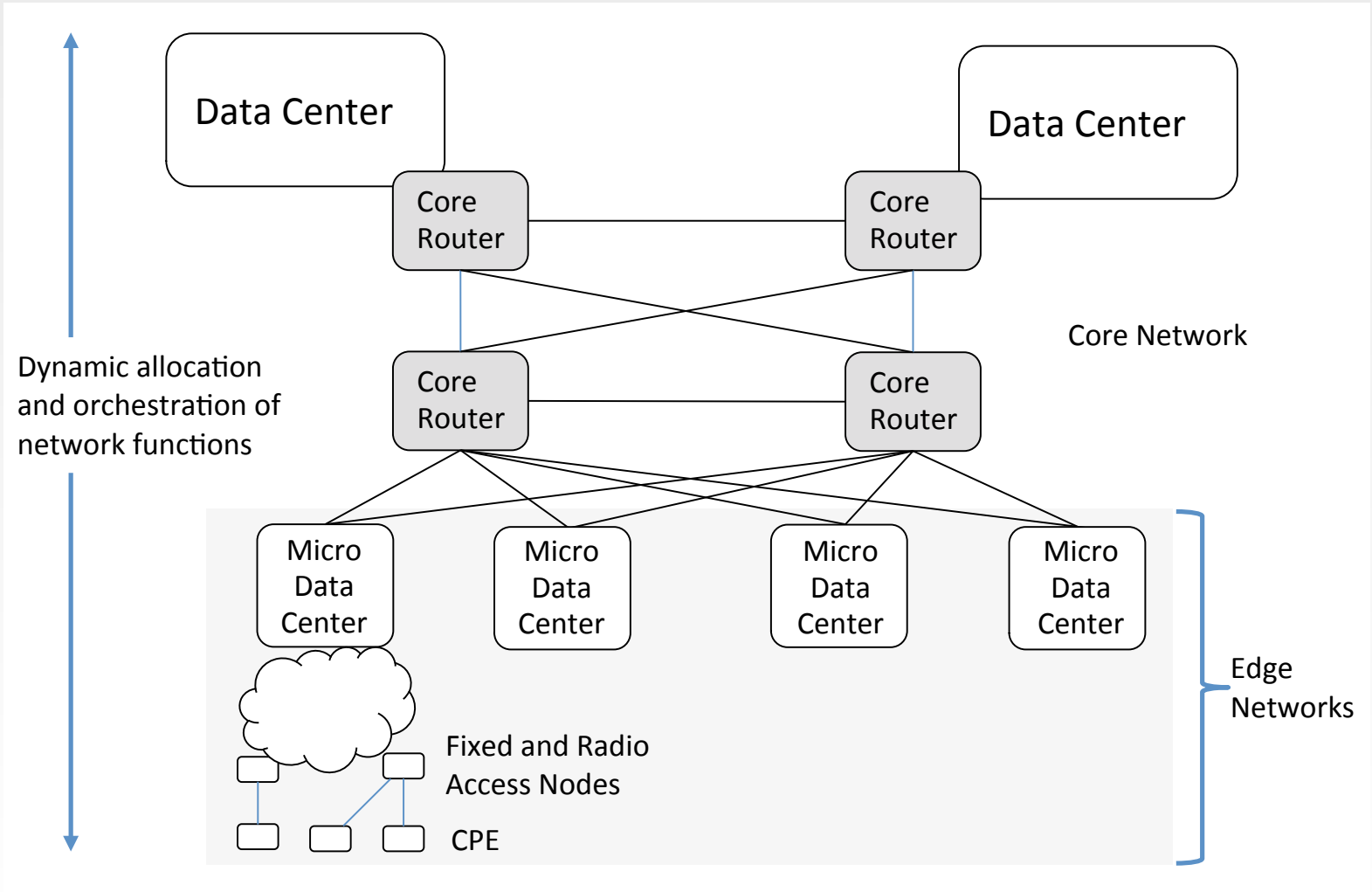
- The edges of the networks will be transformed into complex Micro Data Centers consisting of a number of diverse and autonomous, but inter-related nodes, devices, machines: this will create a "complexity" which has to be managed and controlled.
- Each deployed virtual network is viewed as a *managed network service* by the management software. All managed network services are mapped to the available resources which allows users of the network service to access it, just like they would access a physical network service.

Evolutionary Edge Networks

Evolutionary view of the network.



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- In general, the provisioning of a service involves the creation of an infrastructure, followed by the installation of all necessary software components into the infrastructure, and finally to configure and start those components.
- With SDN and NfV these processes can be simplified as the infrastructure provides a platform from which virtual machines can be run. SDNs can be directly manifested as virtual network topologies which need to be setup, have a managed lifecycle, and need to be shutdown - *all under software control*.

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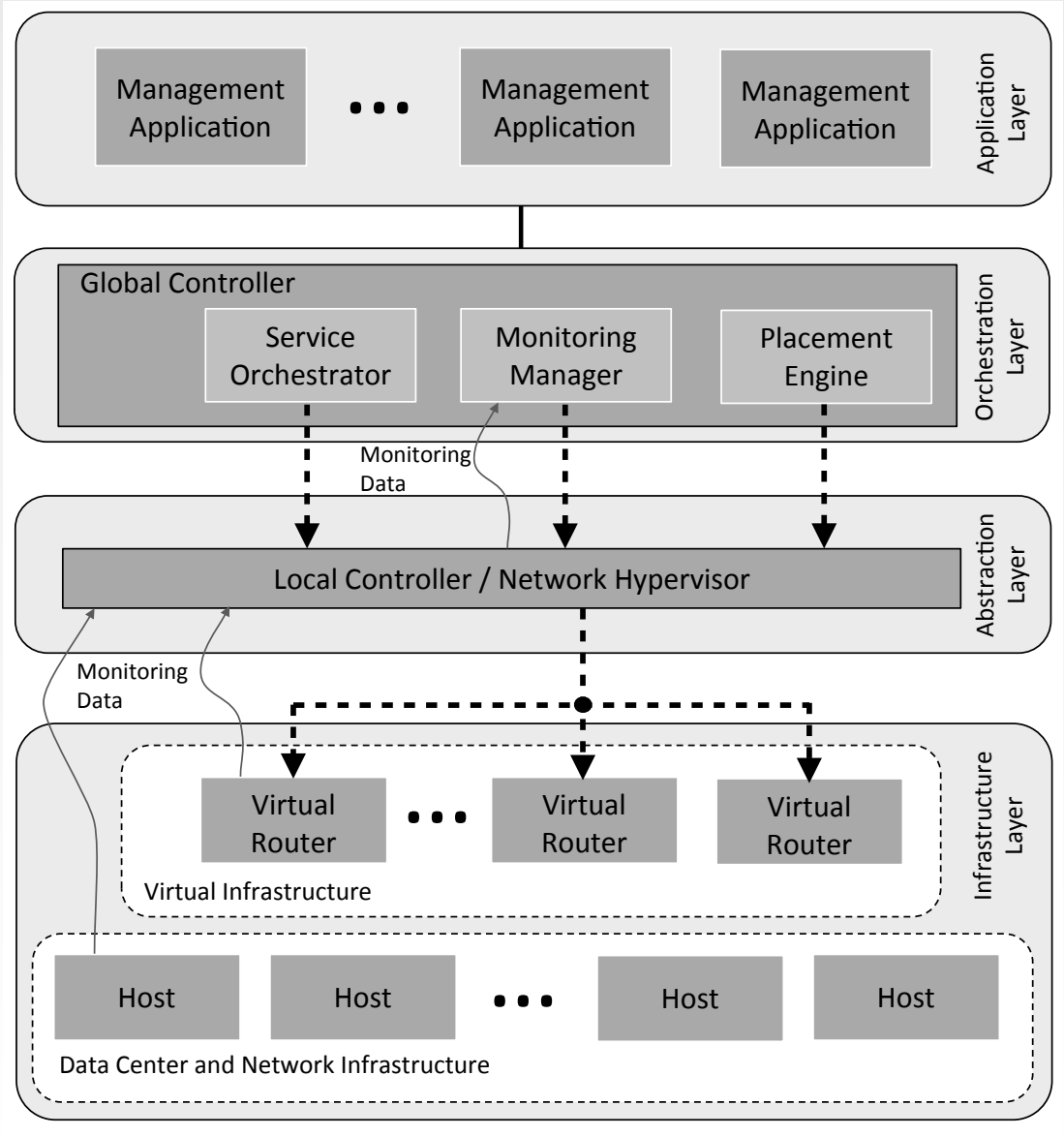
- the *Infrastructure Layer* contains both the *Virtual Infrastructure* which represents the virtual resources (i.e. the virtual routers) that make up the virtual networks, and the *Data Center Infrastructure* which are the physical resources that are the hosts running the VMs.

Overall System Architecture and Components



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- It is an important feature because when we configure a network, some of these parameters may change during the course of the system's operation and a reconfiguration may be required to maintain optimized collection of information.
- The decision on the Placement Engine is encoded in an algorithm which can be rather simple, such as counting the number of virtual routers on a host, or it can be based on a set of constraints and policies that represent the network properties.

Monitoring Manager

- The *Monitoring Manager* is an important component of the architecture and its monitoring function is a vital part of a *full control loop* that goes from the Orchestrator, through a control path, to monitoring probes which collect and send data, back to the Orchestrator which makes decisions based on the data.
- Each virtual router has a probe to monitor the usage of the network resources (e.g. the state congestion of the links). The data provided by the probes is collected by the Monitoring Manager and used by the Orchestrator to create or remove the virtual routers according to the current state of the network.

Validation

- A working implementation of the architecture has been created. The experiments used the Very Lightweight Service Platform (VLSP) which has been implemented by UCL for the purpose of testing and evaluating various aspects of SDN and highly dynamic virtual environments.
- The VLSP testbed consists of a large number of software routers, each running inside JVMs. These virtual routers execute on a smaller number of physical machines. The virtual routers are logically independent software entities which cannot communicate with each other except via network interfaces.
- The testbed has been validated in previous work we have undertaken on virtual networks and highly dynamic networks

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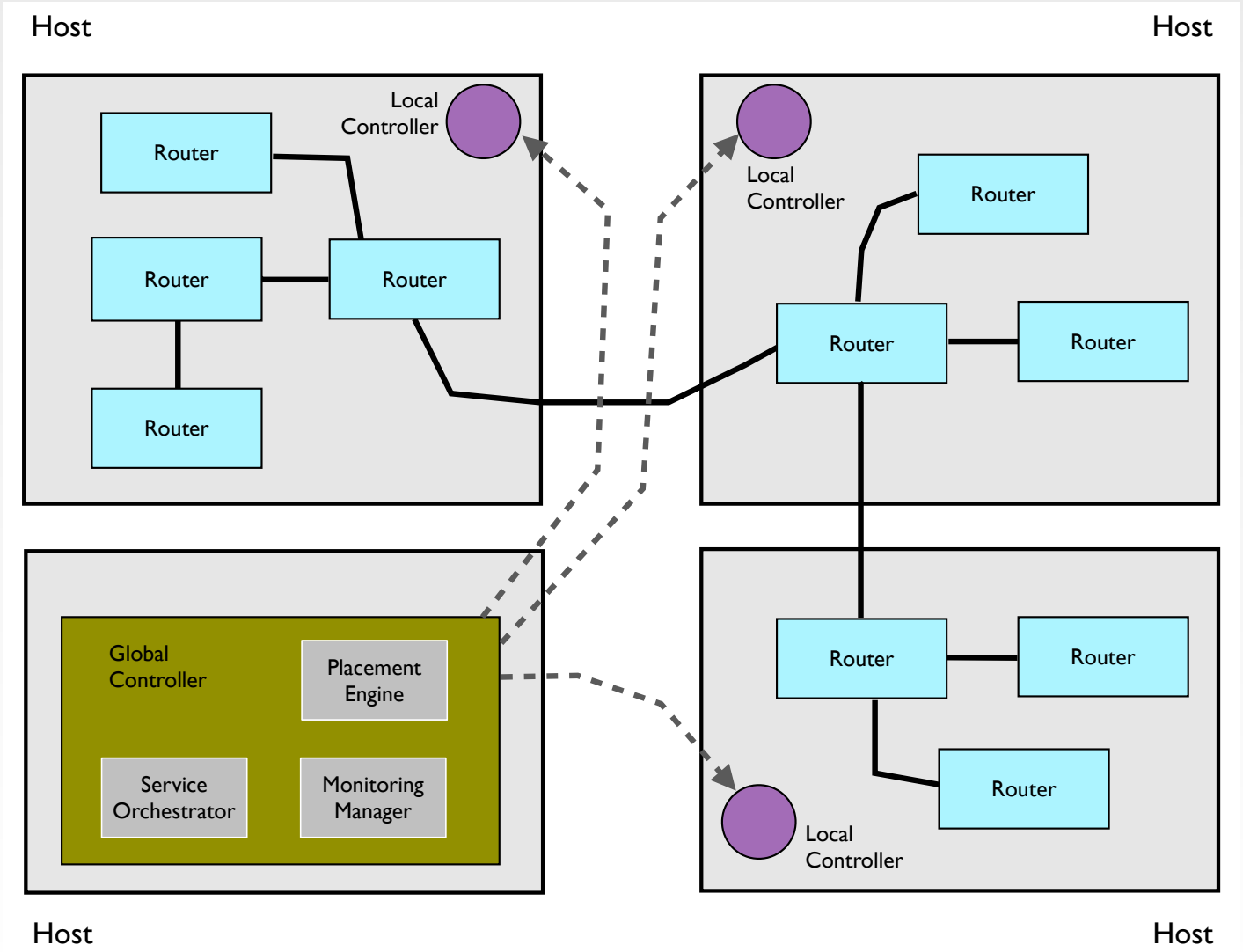
The routers are complemented by a lightweight per-host controller called the *Local Controller* which has the role of sending instructions to start up or shut down routers on the local machine and to inform routers to initiate or tear down connections with other routers.

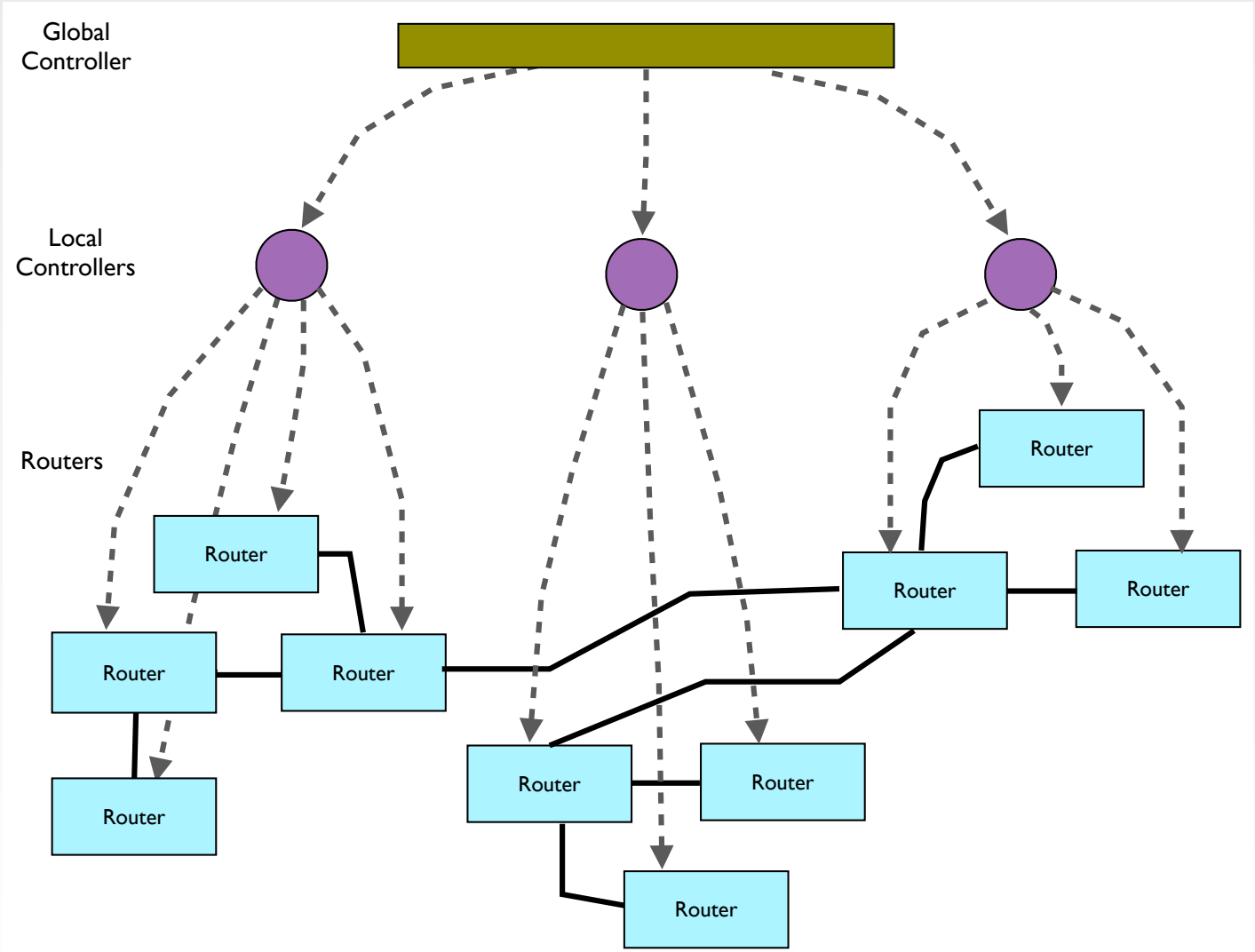
Validation

Mapping and allocation of elements to hosts



Validation

Control path to virtual routers and virtual links



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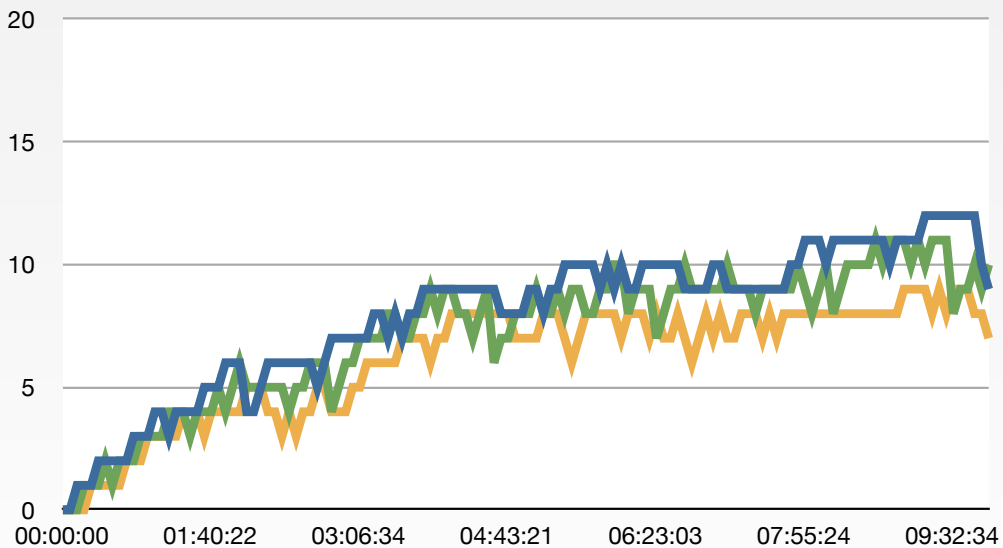
- The choice as to which Placement Engine to run is dependent on the high-level goals and policies that are set for the whole of the networked system.
- There may be a high-level goal which is "reduce energy consumption". To satisfy such a goal, the placement engine needs to have an algorithm which places virtual routers ensuring that the least number of physical resources are used. Conversely, a goal could be "balance the load across all physical nodes".

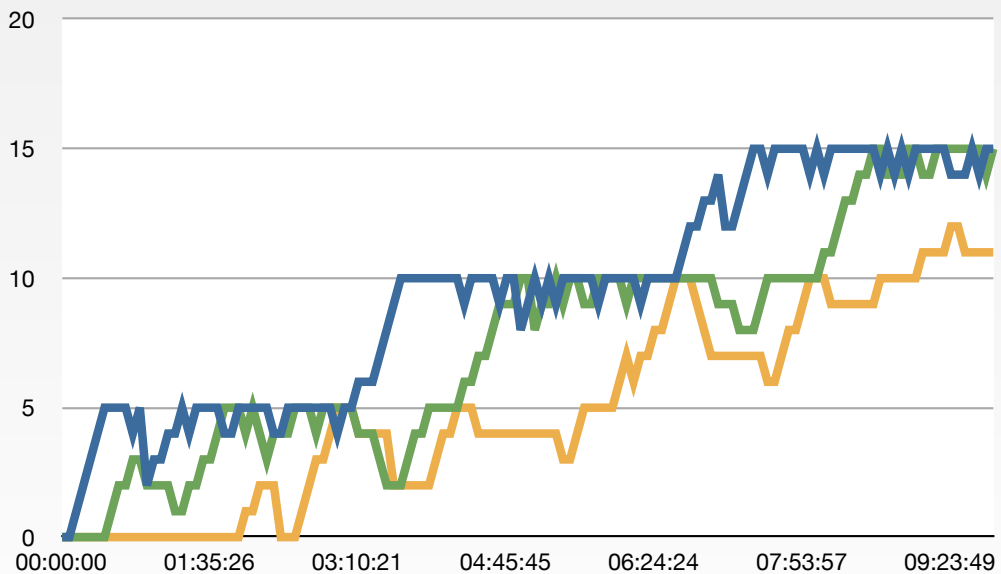
Placement Engine: Least Used

This collects the number of virtual routers allocated to each physical host and chooses the host that has the least number of virtual routers. If more than one host is at the minimum level, then a random host is chosen. This algorithm is a kind of load balancing algorithm as it tries to get a similar number of routers on each host.



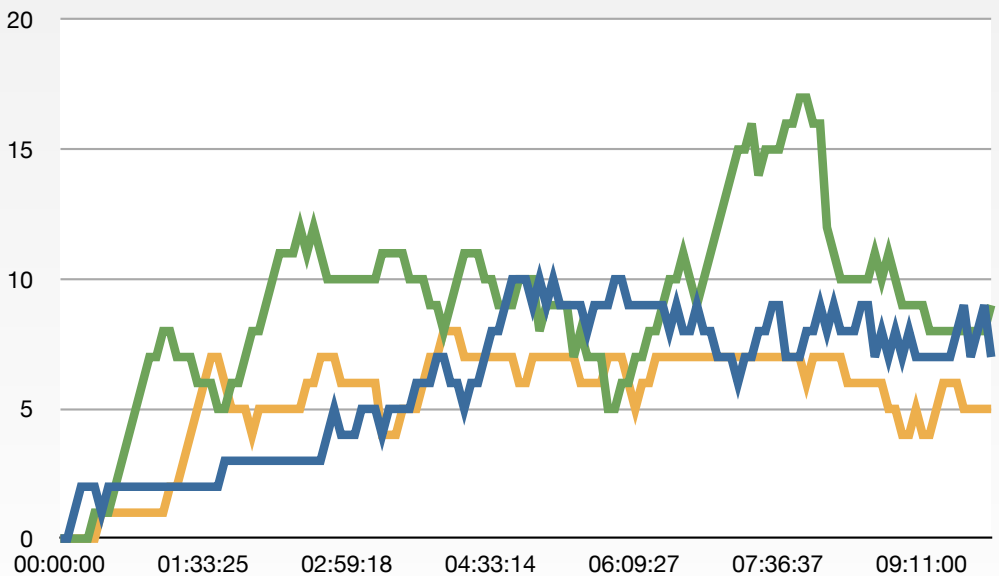
Placement Engine: N at a time: N = 5

Allocates N routers at a time into a single host. In this run, N = 5. If the number of routers is a factor of N, then the algorithm chooses are different host. When all the hosts are packed with a factor of N, then a random host is chosen.



Placement Engine: Least Busy

It tries to determine the host that is *least busy* in terms of virtual network traffic. It collects monitoring data from all the the virtual routers in the virtual network and calculates how much virtual traffic has been sent on each of the hosts. The host that has the lowest amount of traffic since the last placement decision is chosen as the host for the current placement.



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- These placement engines may be able to utilize or share some algorithmic elements from compute cloud placement algorithms.
- It is expected that over time the placement algorithms for virtual routers will become more complex and factor-in metrics from both infrastructure and virtual resources, and also to consider placement across multiple data centers.