An Optimization Case in Support of Next Generation NFV Deployment

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Network Function Virtualization (NFV) concept

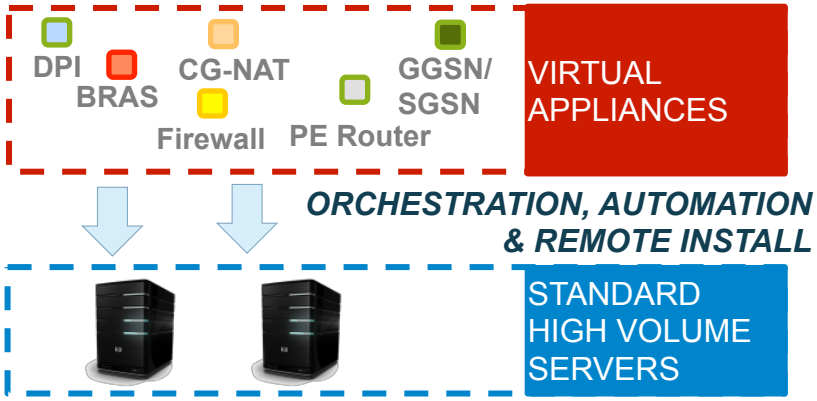
A means to make the network functions more flexible and simple by minimizing dependence on HW constraints

Traditional Network Model: APPLIANCE APPROACH



- Network Functions are **based on specific HW&SW**
- **One physical node per role**

Virtualised Network Model: VIRTUAL APPLIANCE APPROACH



- Network Functions are **SW-based over well-known HW**
- **Multiple roles** over **same HW**

Source: Adapted from D. Lopez Telefonica I+D, NFV

Motivation: NF cloudification



OPPORTUNITIES

- All advantages of virtualization:
  - quick provisioning
  - scalability
  - mobility
  - Reduced CapEx
  - Reduced OpEx, …

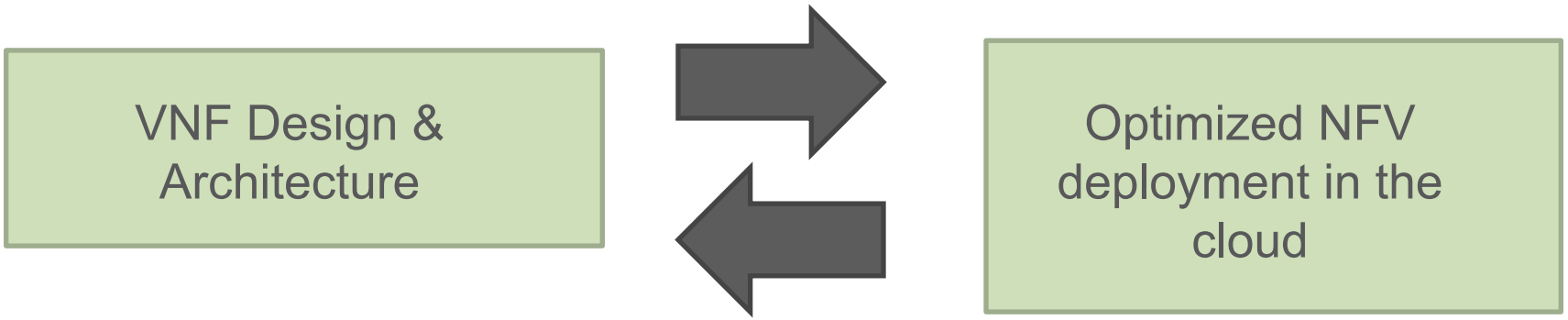
CHALLENGES

- Too many decision parameters
  - Number of VNF Instances
  - VNF placement
  - Service chain installation
- Hard optimization problem

Motivation: optimized NFV deployment



- NFV is more than just softwarization of NFs
  - E.g., Multiple instances per Virtualized Network Functions (VNF)
  - E.g., VNF disaggregation (several virtualized components per NF)



State of the art solutions (cont.)

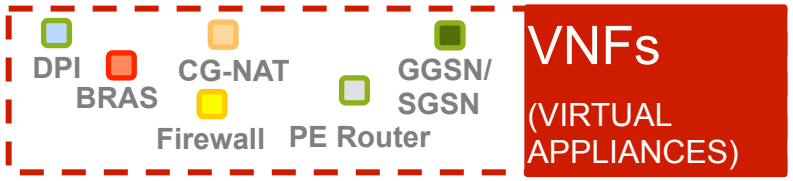


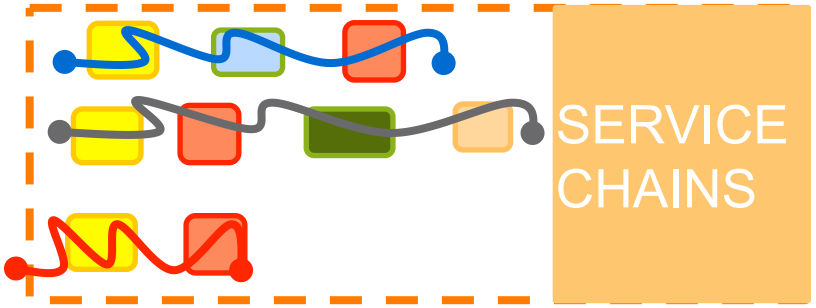
OpenNF, Stratus, ClickOS, Middlepipe etc.	NF cloudification solutions to ensure security, fault tolerance, performance and orchestration efficiency

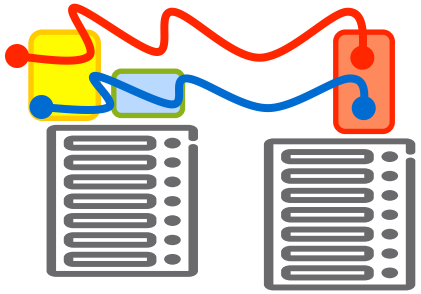
Given virtualized Network Functions, how to deploy VNFs and implement service chains in the cloud in a cost efficient way?

System Model

- VNF Resource Requirements
  - bandwidth/
  - Computations (CPU, Memory)
  - Storage
- Policy Requirements
  - Order
  - Affinity/anti-affinity
  - High availability, etc.
- Business model requirements
  - Do tenants share a VNF instance or not
- Cloud infrastructure and server capacities







Objective: Place VNFs and implement VNF chains in the cloud to optimize
The desired objectives by cloud operators and users

NFV cost model components

Cloud operator

Minimize resource consumption

Minimize OPEX (e.g., energy consumption)

Minimizing computation and networking overhead

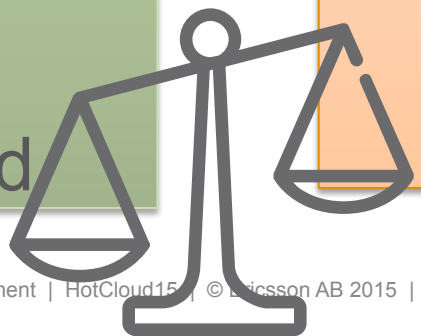
Users

Pay less

Minimize delay

Minimizing computation and networking overhead

Minimizing computation and networking latency

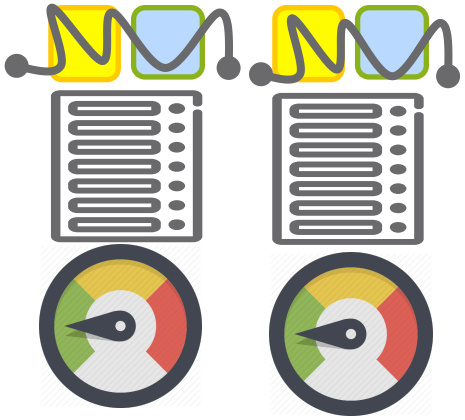


Computation and networking aware NFV deployment



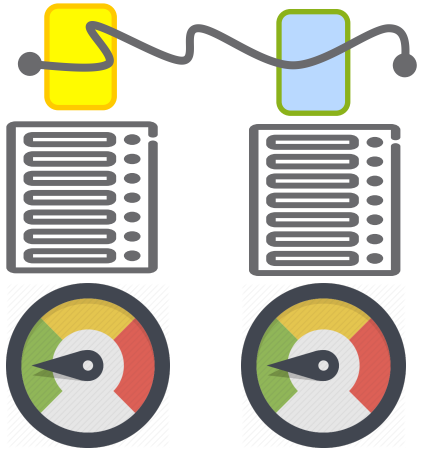
CPU utilization

Network cost efficient deployment





Computation cost efficient deployment



Optimization case for NFV deployment



Cost types:

Computation

networking

Joint optimization of computation and networking cost

Cost contributors:

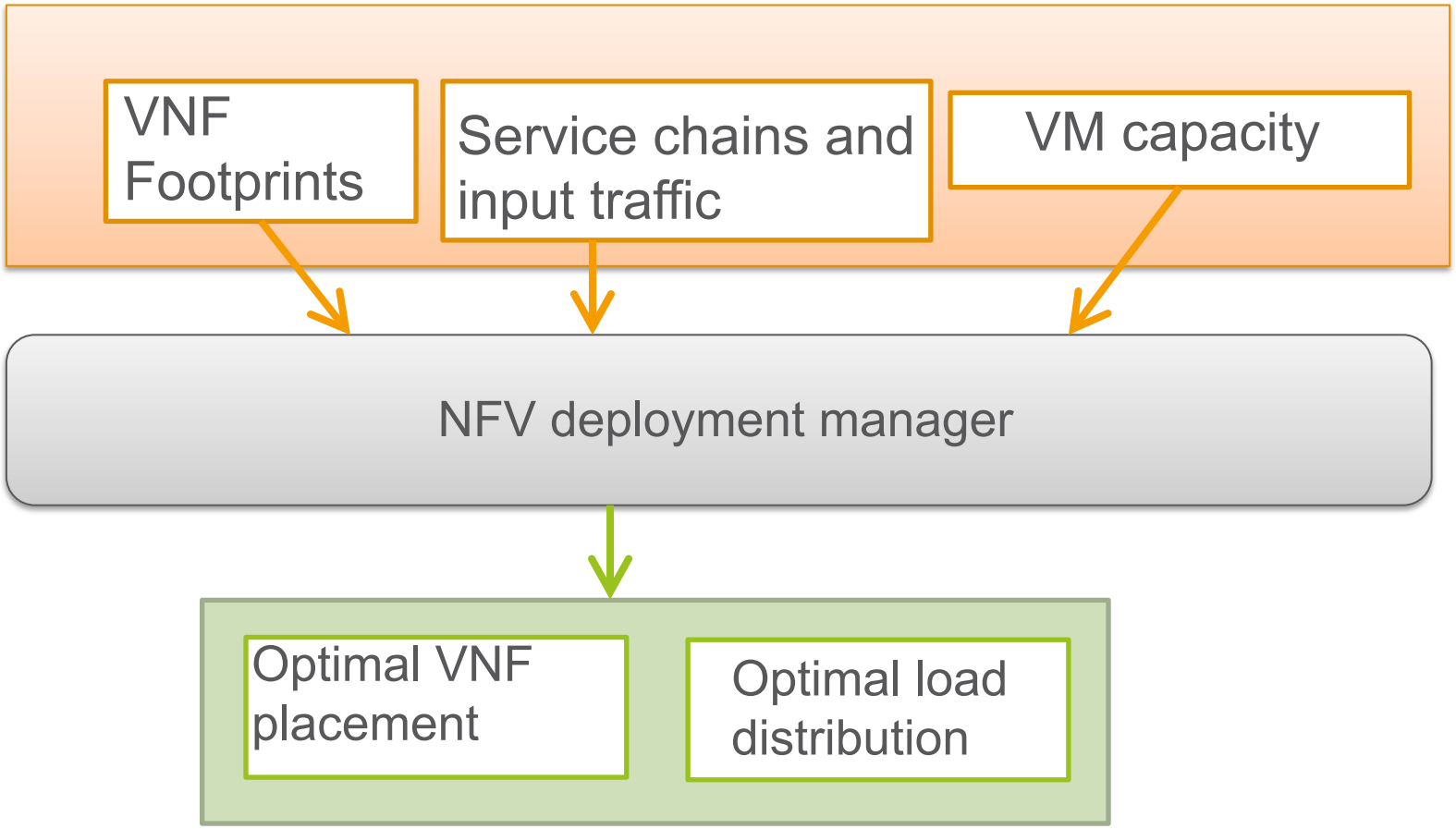
Number of VNF instances

Service chain assignment

Load distribution

Joint VNF placement and load distribution

Optimization problem



Joint optimization of computation and networking cost

Each VNF i: $CompCost_i = CostPerInstance_i \; NoInstances_i$

Each VNF Chain j:

$CommCost_j = CostPerHop \; NoHops_j$

Optimization problem:

Minimize: $\Sigma_i CompCost_i + \Sigma_i CommCost\ j$

Subject to: Data Centers capacity,

input workload

VNF chains

server capacity

Mixed integer programming
(integer knobs to control VNF placement and load distribution):
Theoretically hard to find the optimal solution

Example solutions and results



- Mixed integer programming
- Greedy solution:
  - solve the VNF deployment for every VNF chain one by one given the previous VNF placement decisions.

- Sample results
  - Test bed:
    - Platform: 1.8 GHz Intel core i5, and 8 GB memory
    - Solver: GLPK
  - MILP runtime increasingly grows with increasing the size of problem in terms of number of servers, and number of VNF chain
  - Greedy solution is fast and scalable which comes with increasing the communication cost

Conclusions



- NFV paradigm: New needs and challenges for optimizing VNF placement in the cloud
- Call for efficient algorithms to solve large-scale and complicated NFV deployment problems

Open questions for future work



- Architectural challenges
  - What are the various disaggregation architecture for various NFs
    - how does that impact the traffic model
    - How does that impact the NFV deployment model?
    - How does it impact the optimization modeling and the solution?
- Implementation challenges
  - What are the profiling schemes (online versus offline)
- Algorithmic challenges
  - Online versus offline solutions
    - VNF migration overhead



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