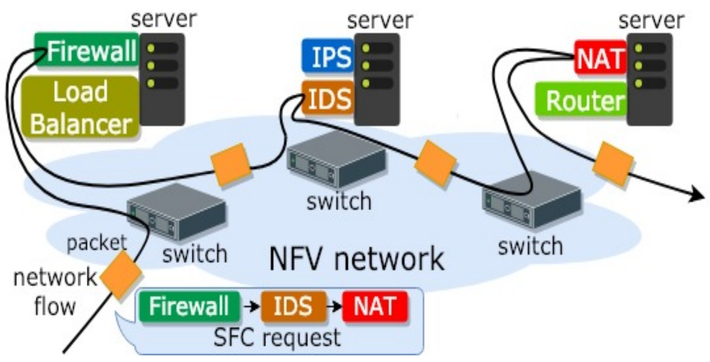
Biochemical-inspired autonomous control of virtualized network functions

Ryota Kurokawa Go Hasegawa Masayuki Murata | Osaka University, Japan

1. Background

Network Function Virtualization (NFV)

- Virtual Network Function (VNF)
- Service Function Chaining (SFC)



Desired NFV system control

- Dynamic control in accordance with SFC requests, traffic demands and server resources
- Distributed control to quickly response to environment changes such as system failures

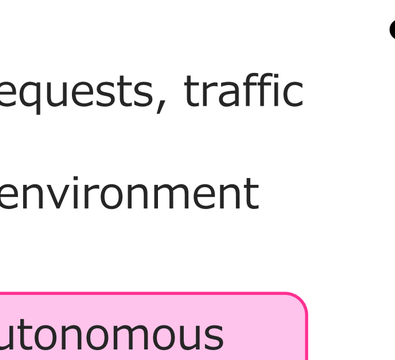
We exploit a biochemical mechanism with autonomous dispersibility and self organization

2. System modeling by tuple space model

The behaviors in the NFV system are expressed by biochemical reactions in the tuple space

- A tuple space is a cell where biochemical reactions occur
- Tuples in the tuple space correspond to chemical substances
- With multiple tuple spaces, diffusion and movement of substances are described

Since biochemical reactions in each tuple space occur independently, autonomous decentralized behaviors can be described



Apply the tuple space model to NFV

Tuple space model	NFV system
Tuple space	General-purpose server
Chemical substances	VNF demands, flow packets, server resources, and so on
Biochemical Reactions	Apply VNFs to the packet, server resource allocation to each VNF, diffusion of VNFs, packet forwarding, and so on

3. Biochemical reaction equations for NFV system

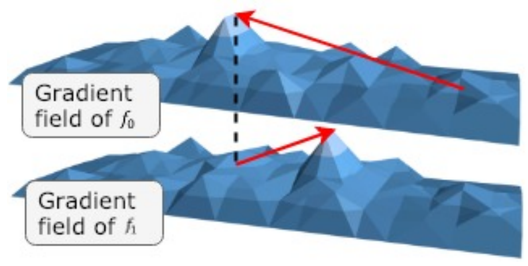
$$
\begin{aligned}
VNF \mid PKT \mid RSRC &\rightleftarrows MEDIATE && \text{Resource allocation to VNFs}\\
MEDIATE &\rightarrow VNF \mid VNF \mid PKT \mid RSRC \mid toserve && \text{Execution of VNFs}\\
VNF &\rightarrow 0 && \text{Decay of VNFs}\\
VNF &\rightarrow VNF^{\sim} && \text{Diffusion of VNFs}
\end{aligned}
$$

VNF: VNF demand PKT: flow packets $MEDIATE$: server resources allocated to VNF

$RSRC$: server resources $toserve$: result of applying the VNF to flow packets

- We exploit a gradient field for packet forwarding
  - ○ A gradient field for each VNF is constructed on the basis of the VNF demands and the available resources
  - ○ Packets move to high gradient field

$$
\begin{aligned}
VNF \mid RSRC &\rightarrow VNF \mid RSRC \mid GRAD\\
GRAD &\rightarrow 0\\
GRAD &\rightarrow GRAD^{\sim}\,(\,GRAD^{-}\,)\\
PKT &\rightarrow PKT^{\sim}\,(\,GRAD^{+}\,)
\end{aligned}
$$

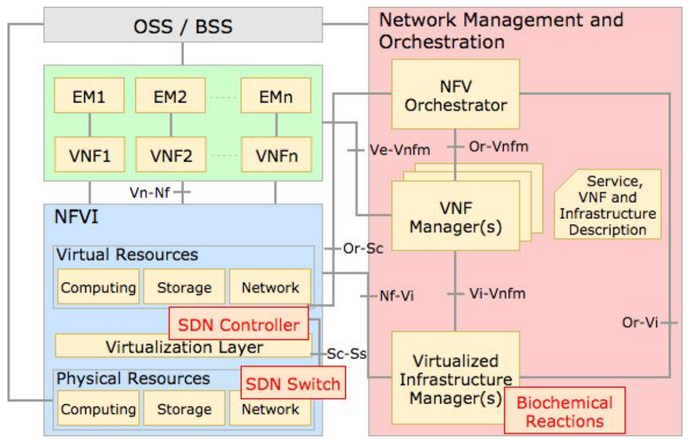


$GRAD$: gradient field for VNF

4. Implementation design of the proposed method

NFV/SDN framework proposed by ETSI

- VNF, NFVI, NFV MANO(VIM, VNFM, NFVO)
- SDN Switch, Controller



Extension of NFV/SDN framework

- Placement of Biochemical Reactions (BRs)
  - ○ BR creates a tuple space and execute biochemical reaction equations
- Resource allocation to each VNF
- Adaptive load distribution of VNFs
- Diffusion and aggregation of VNFs

Implementation environment

- NFV system is constructed with OPNFV that implements the NFV framework with OSS

5. Implementation design of SFC

Network Service Header (NSH)

- A header to control the flow with an SFC request

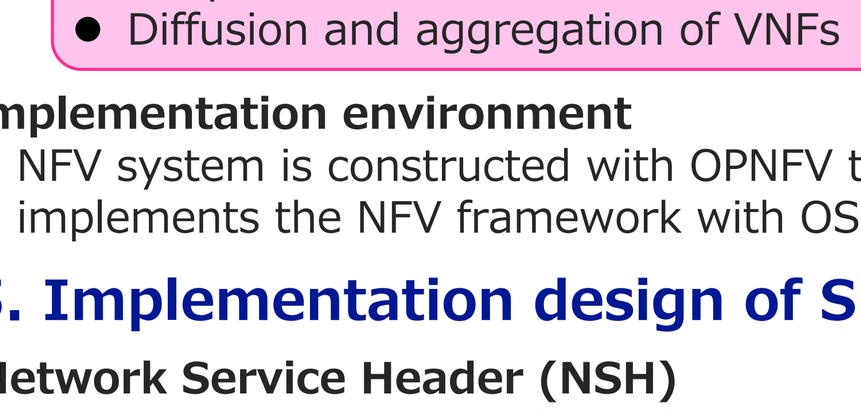
Service Path Header is implemented to identify the next VNF to be executed.

- We exploit encapsulation and decapsulation functions of OpenFlow

Service Function Path (SFP)

- A flow route with locations of server in which required VNFs exist

SFP is managed by NFVO



6. Future work

- Implementation and evaluation the proposed method
- Extension of the proposed method
  - ○ Describe the effect of the propagation delay and link bandwidth