Fluid single server conflict model with integral constraints

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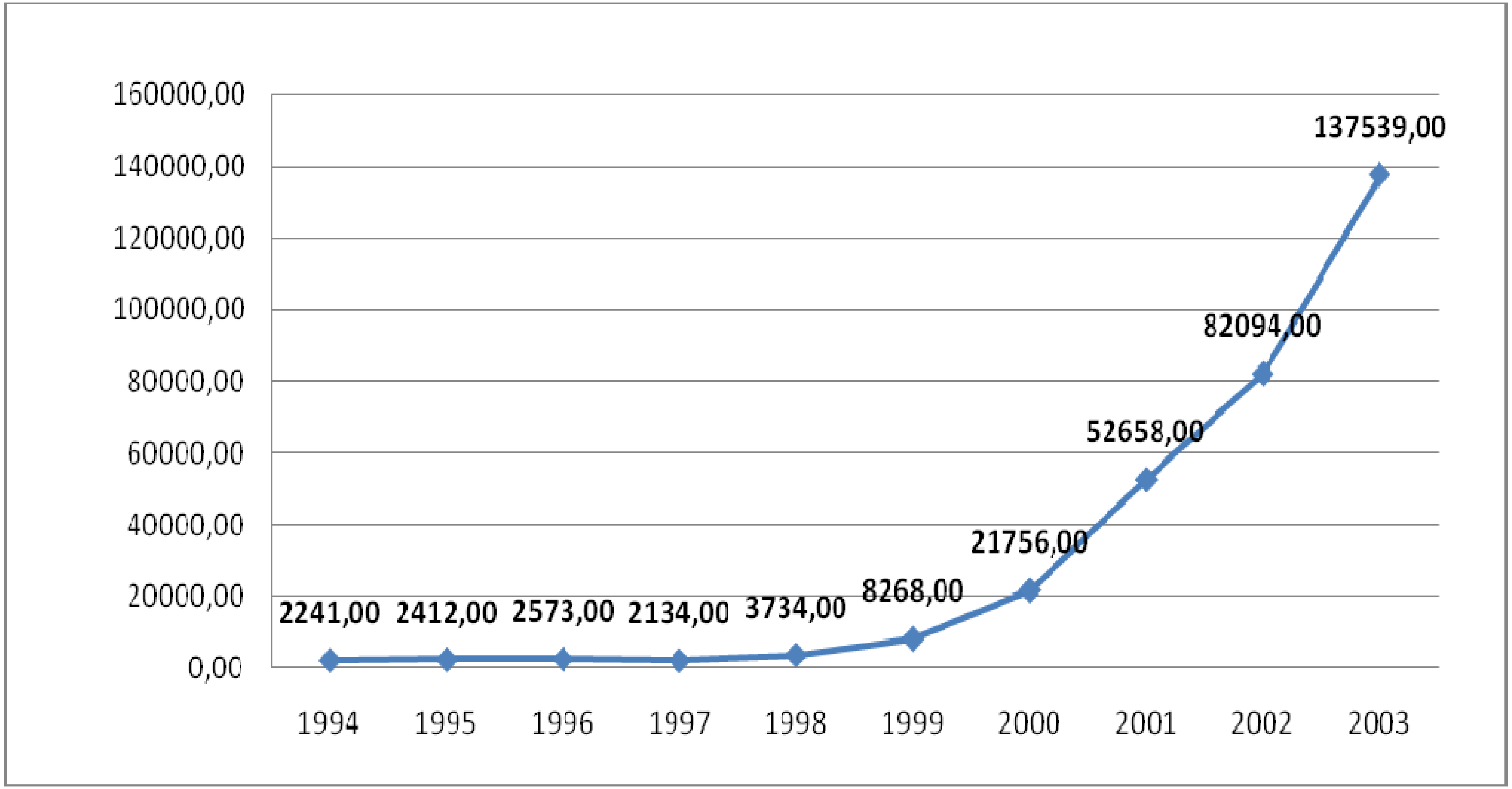
Motivation

- Today network model are related to very different areas
  - Information networks
  - Telecommunications
  - Energy systems
  - Distributed production processes
- Modeling for the purposes of control and the development of control techniques for truly complex networks has become a major research activity over the past two decades.

Number of security incidents (CERT)



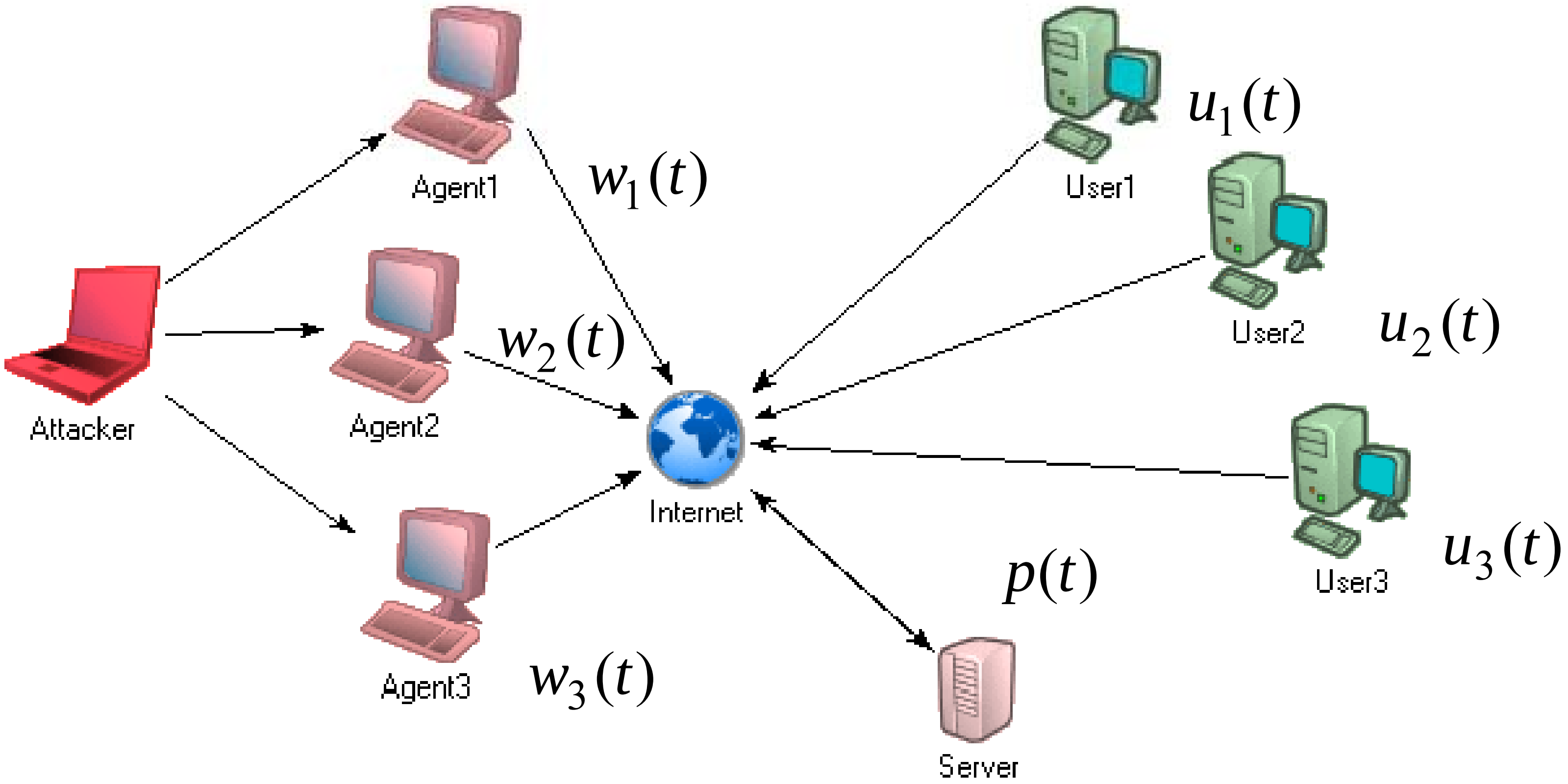
Malicious activity in Internet

- Spam
- Denial of service attacks
- Unauthorized intrusion
- Stealing of information
- Fishing
- Viruses and worms

Main targets of attacks

№	Direction	Attack percent (%)
1	Internet providers	38
2	Governmental facilities	32
3	Telecommunications	8
4	Transport	4
5	Education	3

Typical DoS attack scheme



Model building

$q_1(t)$ - queuing time

$\alpha(t)$ - packets arrival rate

$u_1(t)$ - routing policy

$$\dot{q}_1 = \alpha(t) + u_1(t)$$

Constraints

We consider two constraint types for model

- Geometric constraints

$$0 \le q_1(t) \le q_{1\max} \qquad\qquad 0 \le \alpha(t) \le \alpha_{\max}$$

- Integral constraint

$$\int_{t_0}^{\infty} \alpha(t)\,dt \le \alpha_{\mathrm{int}}$$

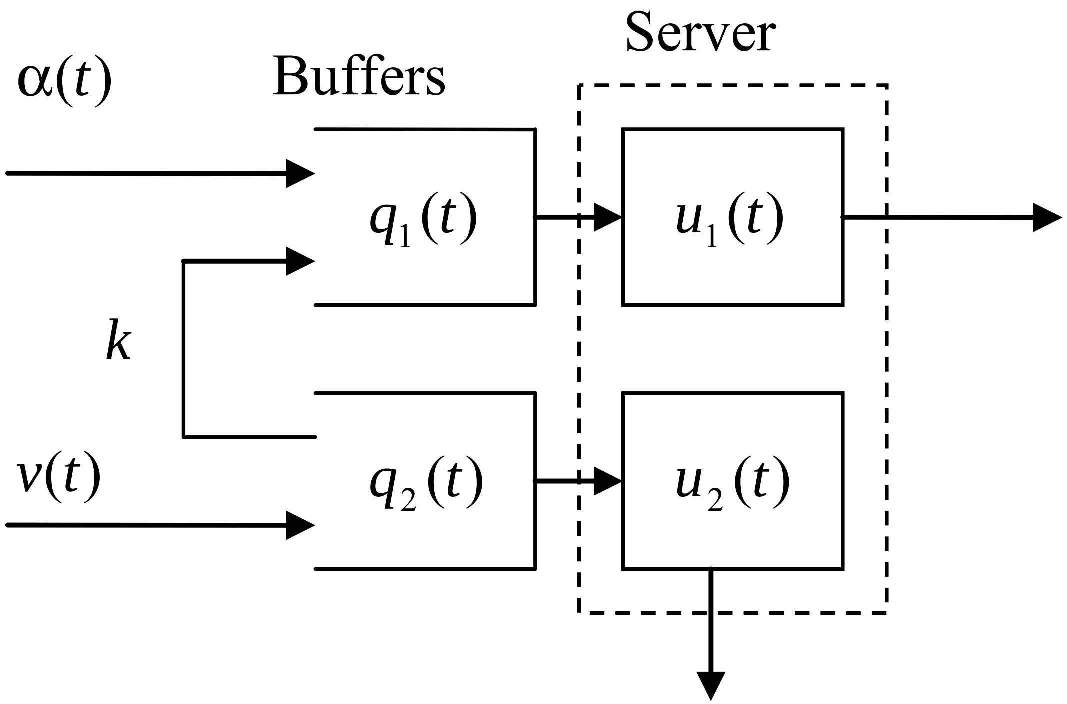
Model building 2

$q_2(t)$ - attack power

$$\dot{q}_1(t) = \alpha(t) - u_1(t) + k \cdot q_2(t)$$

$$\dot{q}_2(t) = v(t)$$

Final model



$$\dot{q}_1(t) = k \cdot q_2(t) + \alpha(t) - u_1(t)$$

$$\dot{q}_2(t) = v(t) - u_2(t)$$

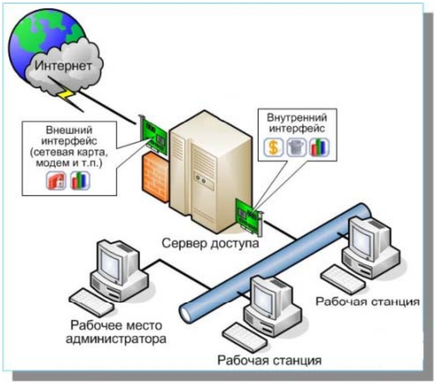
$$u_1(t) + u_2(t) \le \mu$$

Main theoretical result

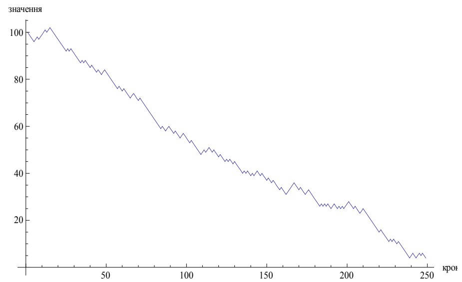
$$\mu > v$$

$$q_1(0) + \frac{k}{2}\frac{(q_2(0))^2}{\mu - \nu} + \alpha_{\mathrm{int}} \leq q_1^{\max}$$

Real Network



Stochastic model

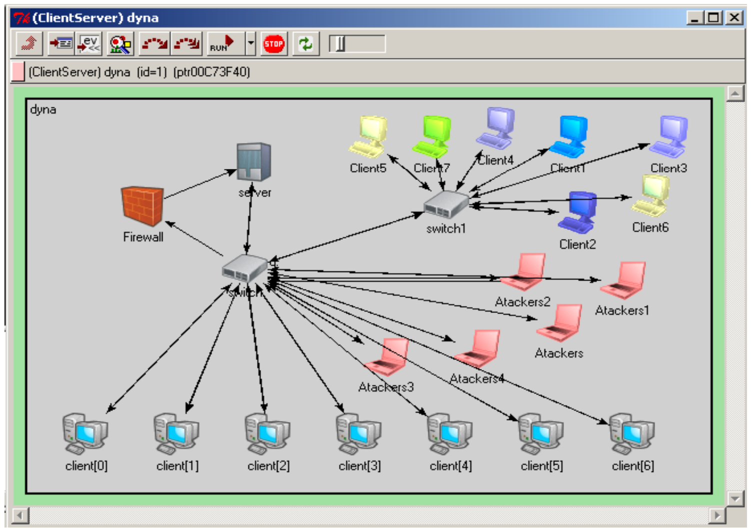


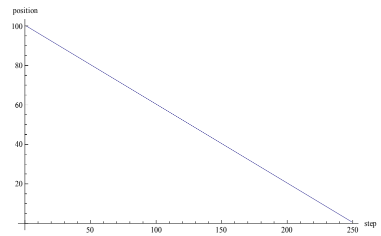
$$Q(t+1) = Q(t) + B(Z(t)) + A(t) + V(t)$$

Deterministic discrete model

$$q(t+1) = q(t) + b(u(t)) + a(t) + v(t)$$

OMNeT++ model

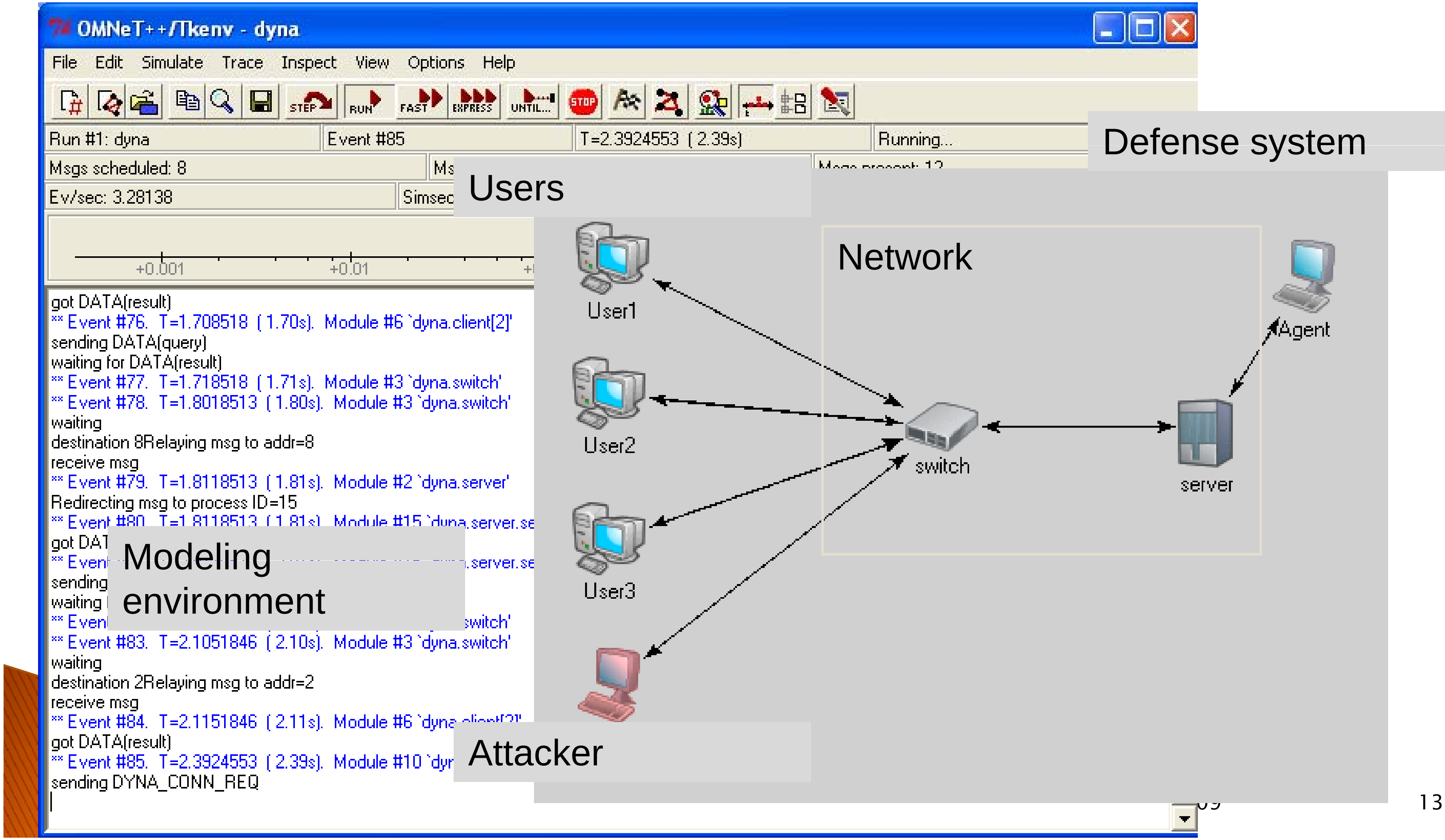


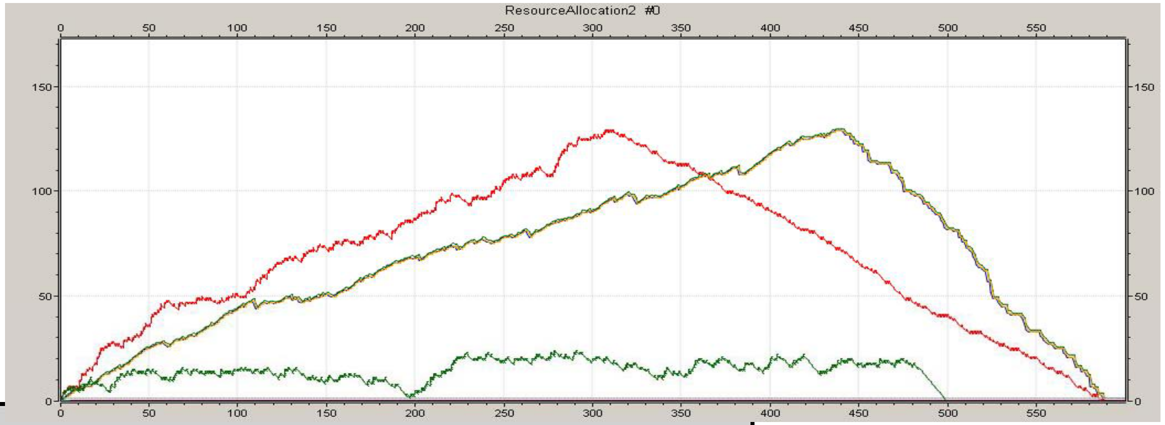


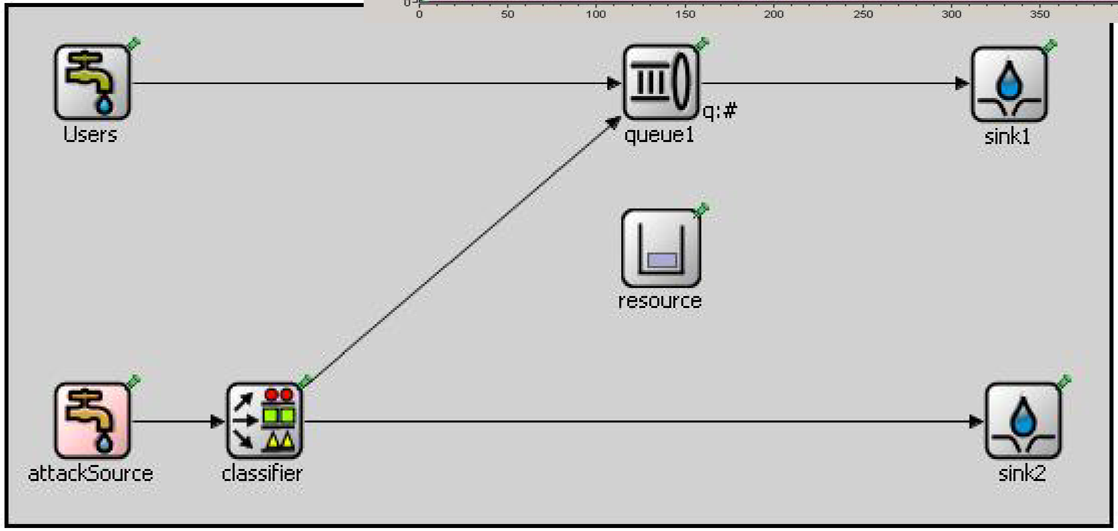
Deterministic fluid model

$$\dot{q} = B(u(t)) + \alpha(t) + v(t)$$

Network modeling environment




ResourceAllocation2 #0


Users
queue1
q:#
sink1
resource
attackSource
classifier
sink2

Thanks