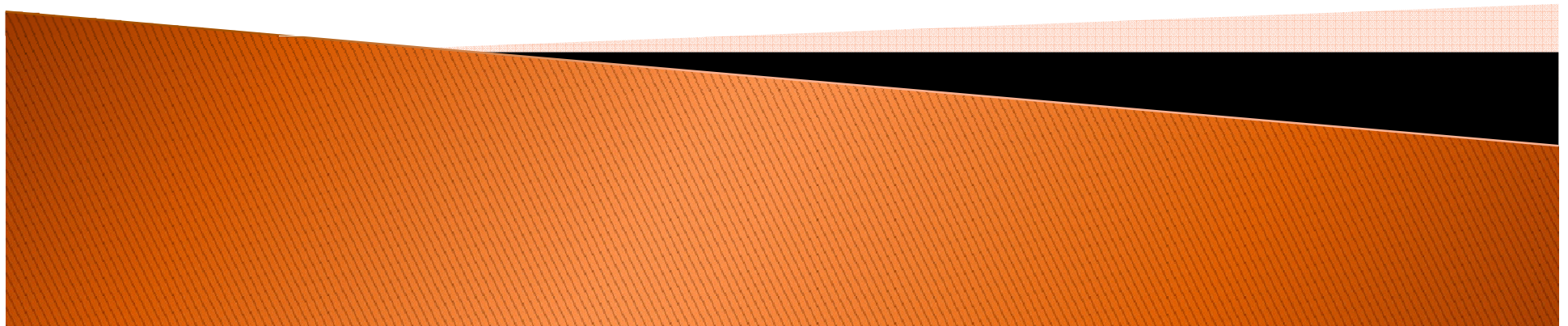


Fluid single server conflict model with integral constraints

Ignatenko Oleksii

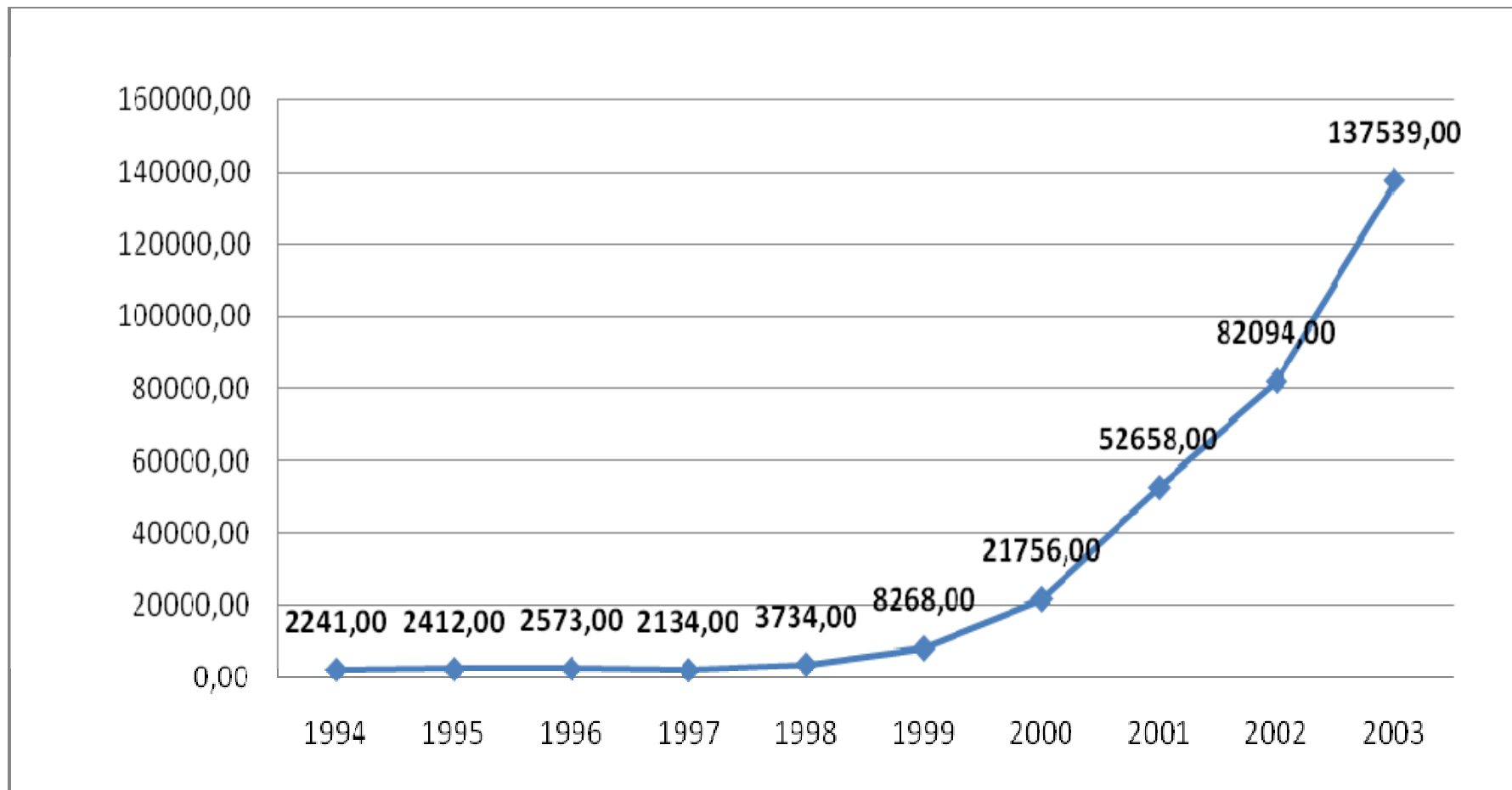
Institute of Software System NAS Ukraine



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)



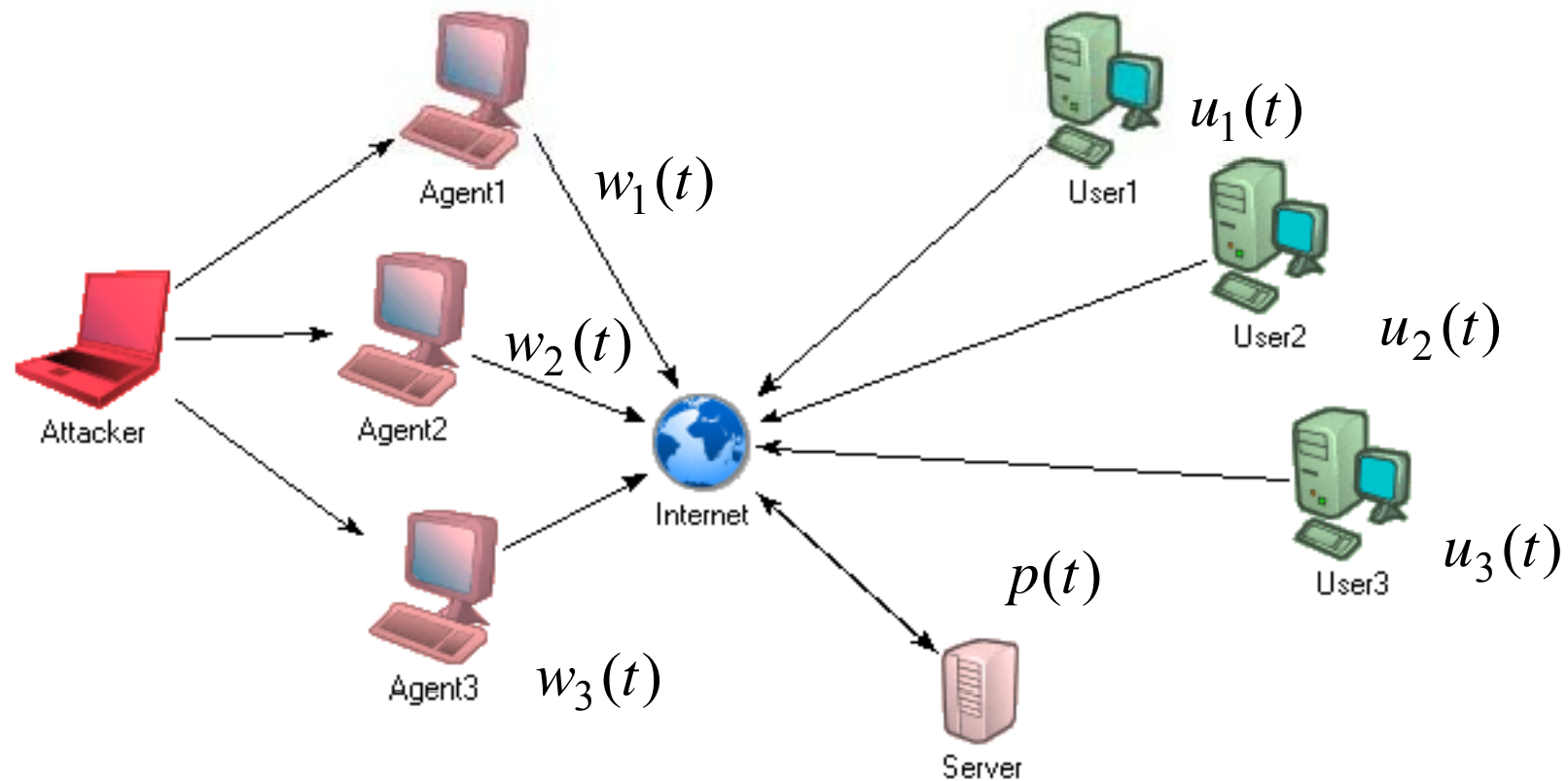
Malicious activity in Internet

- ▶ 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

$$0 \leq q_1(t) \leq q_{1\max}$$

$$0 \leq \alpha(t) \leq \alpha_{\max}$$

- ▶ Integral constraint

$$\int_{t_0}^{\infty} \alpha(t) dt \leq \alpha_{\text{int}}$$

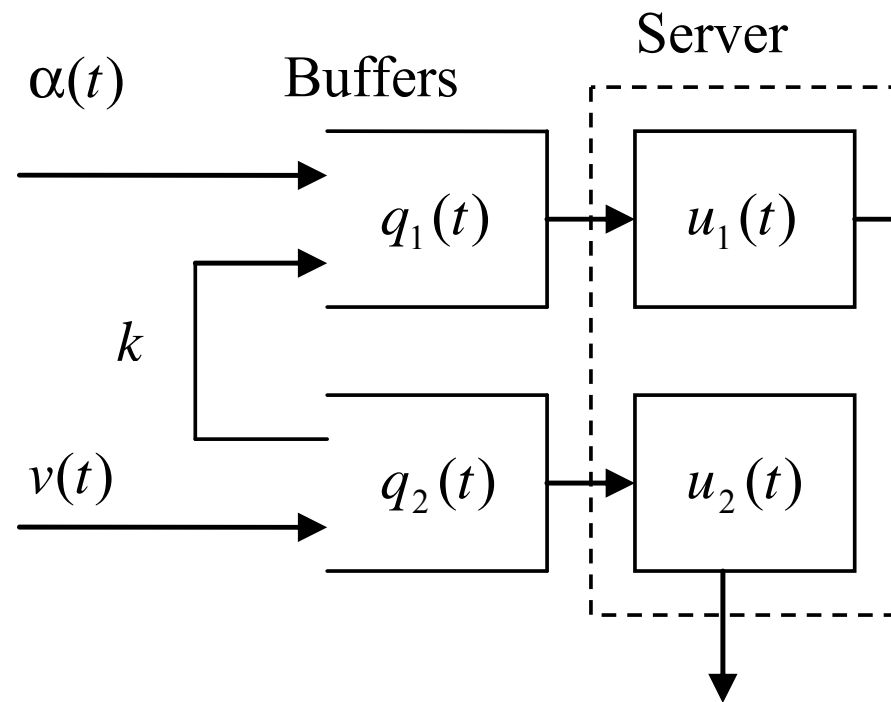
Model building 2

$q_2(t)$ - attack power

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

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

Final model



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

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

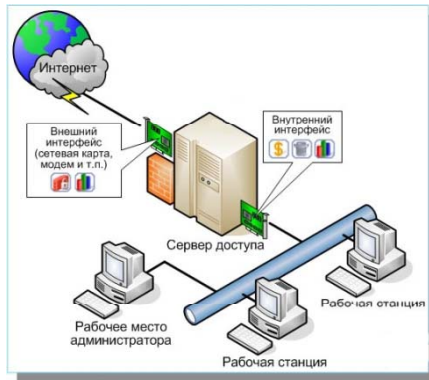
$$u_1(t) + u_2(t) \leq \mu$$

Main theoretical result

$$\mu > \nu$$

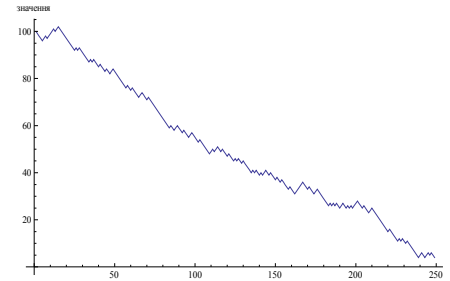
$$q_1(0) + \frac{k}{2} \frac{(q_2(0))^2}{\mu - \nu} + \alpha_{\text{int}} \leq q_1^{\text{max}}$$

Real Network



Stochastic model

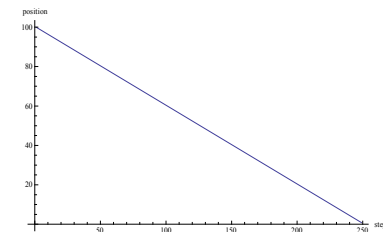
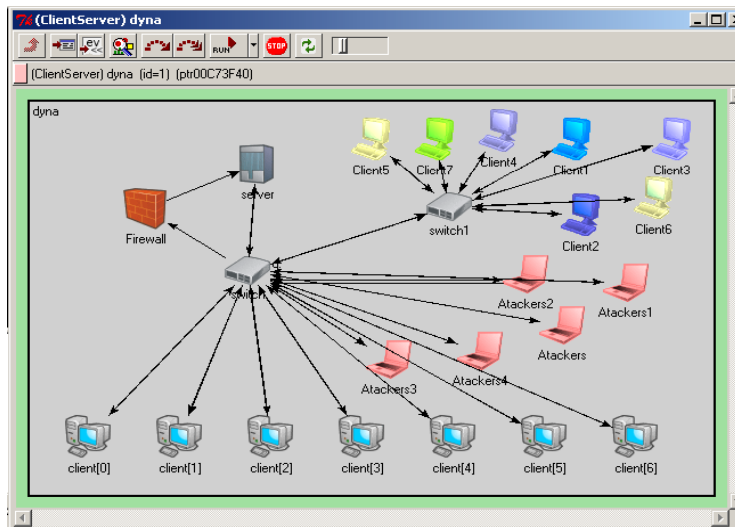
$$Q(t + 1) = Q(t) + B(Z(t)) + A(t) + V(t)$$



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

OMNeT++/Tkenv - dyna

File Edit Simulate Trace Inspect View Options Help

Run #1: dyna Event #85 T=2.3924553 (2.39s) Running...

Msgs scheduled: 8 Ms

Ev/sec: 3.28138 Simsec

Users

Defense system

Network

User1

User2

User3

switch

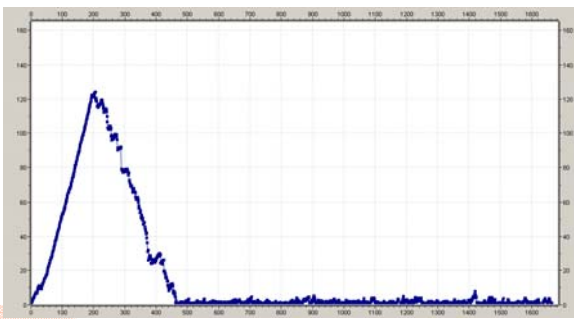
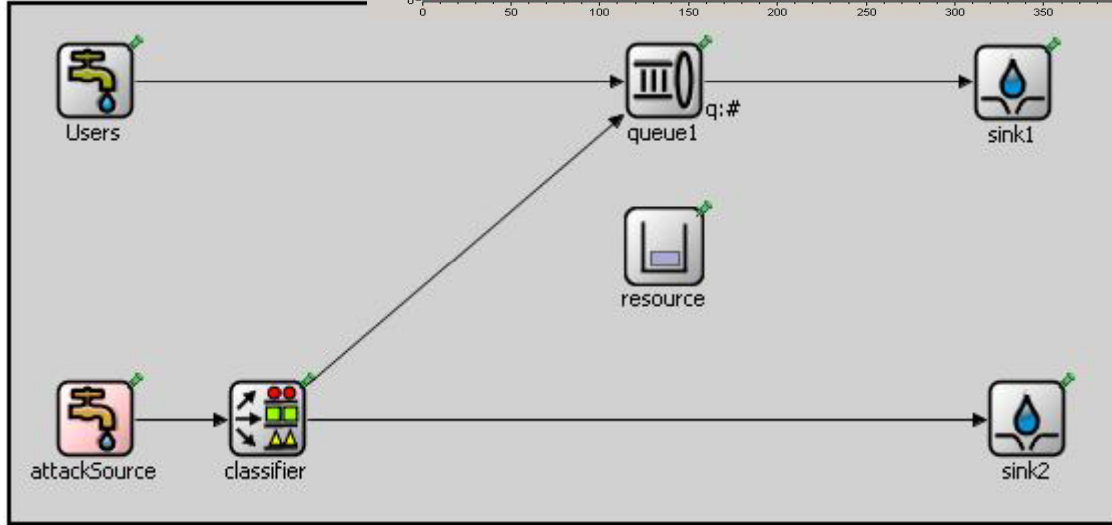
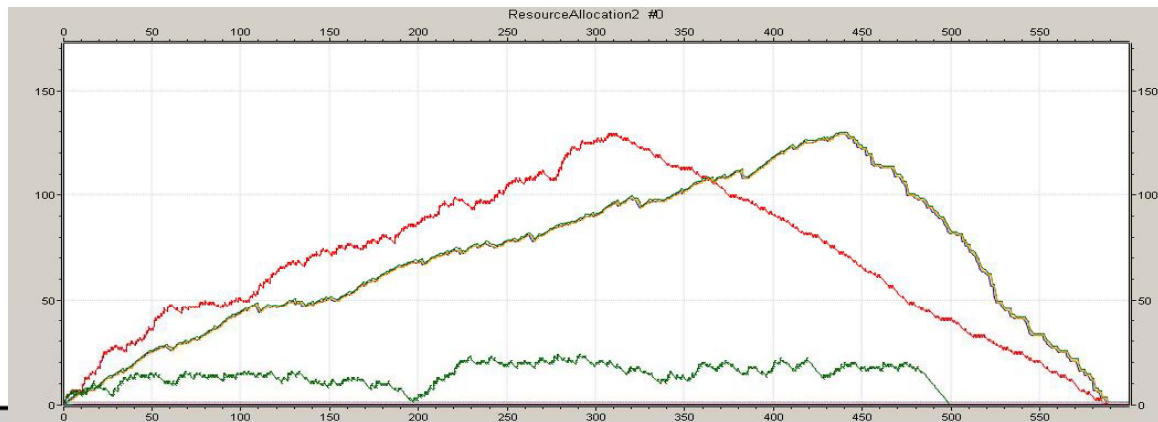
server

Agent

Modeling environment

Attacker

```
got DATA(result)
*** Event #76. T=1.708518 ( 1.70s). Module #6 `dyna.client[2]`
sending DATA(query)
waiting for DATA(result)
*** Event #77. T=1.718518 ( 1.71s). Module #3 `dyna.switch`
*** Event #78. T=1.8018513 ( 1.80s). Module #3 `dyna.switch`
waiting
destination 8Relaying msg to addr=8
receive msg
*** Event #79. T=1.8118513 ( 1.81s). Module #2 `dyna.server`
Redirecting msg to process ID=15
*** Event #80. T=1.8118513 ( 1.81s). Module #15 `dyna.server.se
got DA1
*** Event
sending
waiting
*** Event
*** Event #83. T=2.1051846 ( 2.10s). Module #3 `dyna.switch`
waiting
destination 2Relaying msg to addr=2
receive msg
*** Event #84. T=2.1151846 ( 2.11s). Module #6 `dyna.client[2]`
got DATA(result)
*** Event #85. T=2.3924553 ( 2.39s). Module #10 `dya
sending DYNA_CONN_REQ
```



Thanks