Fluid single server conflict model with integral constraints

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Motivation

- Today network models 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

<table>
<thead>
<tr>
<th>№</th>
<th>Direction</th>
<th>Attack percent (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Internet providers</td>
<td>38</td>
</tr>
<tr>
<td>2</td>
<td>Governmental facilities</td>
<td>32</td>
</tr>
<tr>
<td>3</td>
<td>Telecommunications</td>
<td>8</td>
</tr>
<tr>
<td>4</td>
<td>Transport</td>
<td>4</td>
</tr>
<tr>
<td>5</td>
<td>Education</td>
<td>3</td>
</tr>
</tbody>
</table>
Typical DoS attack scheme

![Diagram showing the typical DoS attack scheme with vectors $w_1(t)$, $w_2(t)$, and $w_3(t)$ towards the internet and vectors $u_1(t)$, $u_2(t)$, and $u_3(t)$ towards a server.](image-url)
Model building

\[ q_1(t) \quad - \text{queuing time} \]
\[ \alpha(t) \quad - \text{packets arrival rate} \]
\[ u_1(t) \quad - \text{routing policy} \]

\[ \dot{q}_1 = \alpha(t) + u_1(t) \]
Constraints

We consider two constraint types for model

- Geometric constraints
  \[ 0 \leq q_1(t) \leq q_{1\text{max}} \quad 0 \leq \alpha(t) \leq \alpha_{\text{max}} \]

- 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
Thanks