



ПЕРМСКИЙ НАЦИОНАЛЬНЫЙ ИССЛЕДОВАТЕЛЬСКИЙ
ПОЛИТЕХНИЧЕСКИЙ УНИВЕРСИТЕТ

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Improving Predictability of Adaptive Q-Routing

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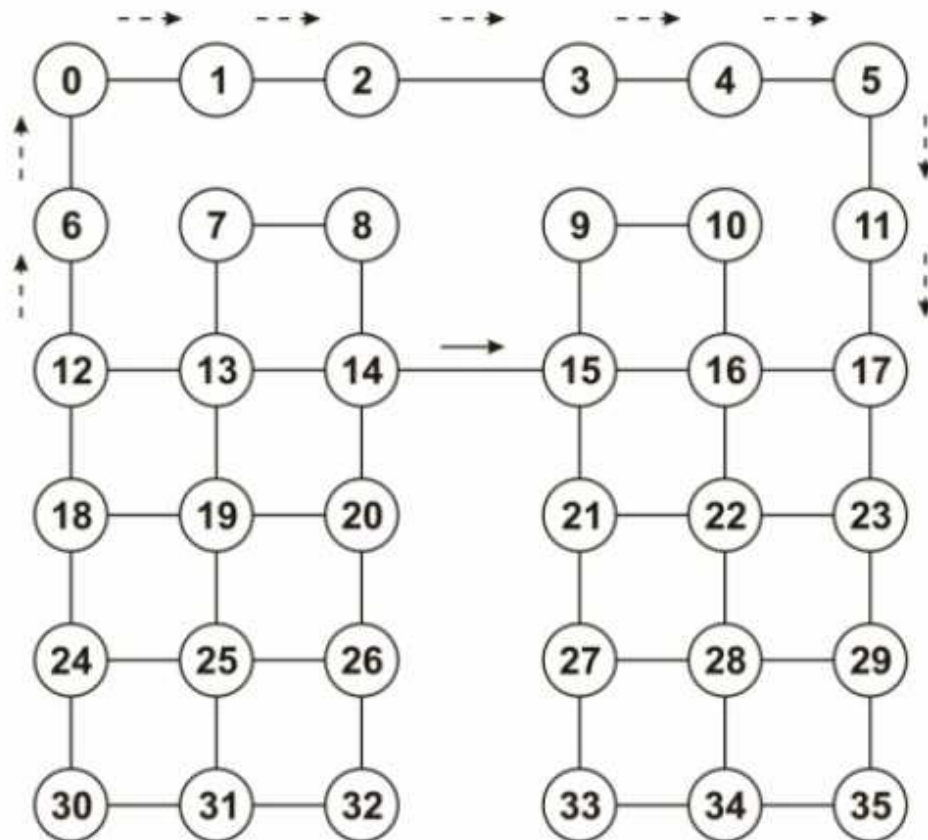
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- Mobile ad hoc networks
- Internet of Things
- Wireless sensor networks
- Vehicular ad hoc networks
- Cyber-Physical systems

- end-to-end delays
- jitters
- loss of packets
- unpredictable behavior

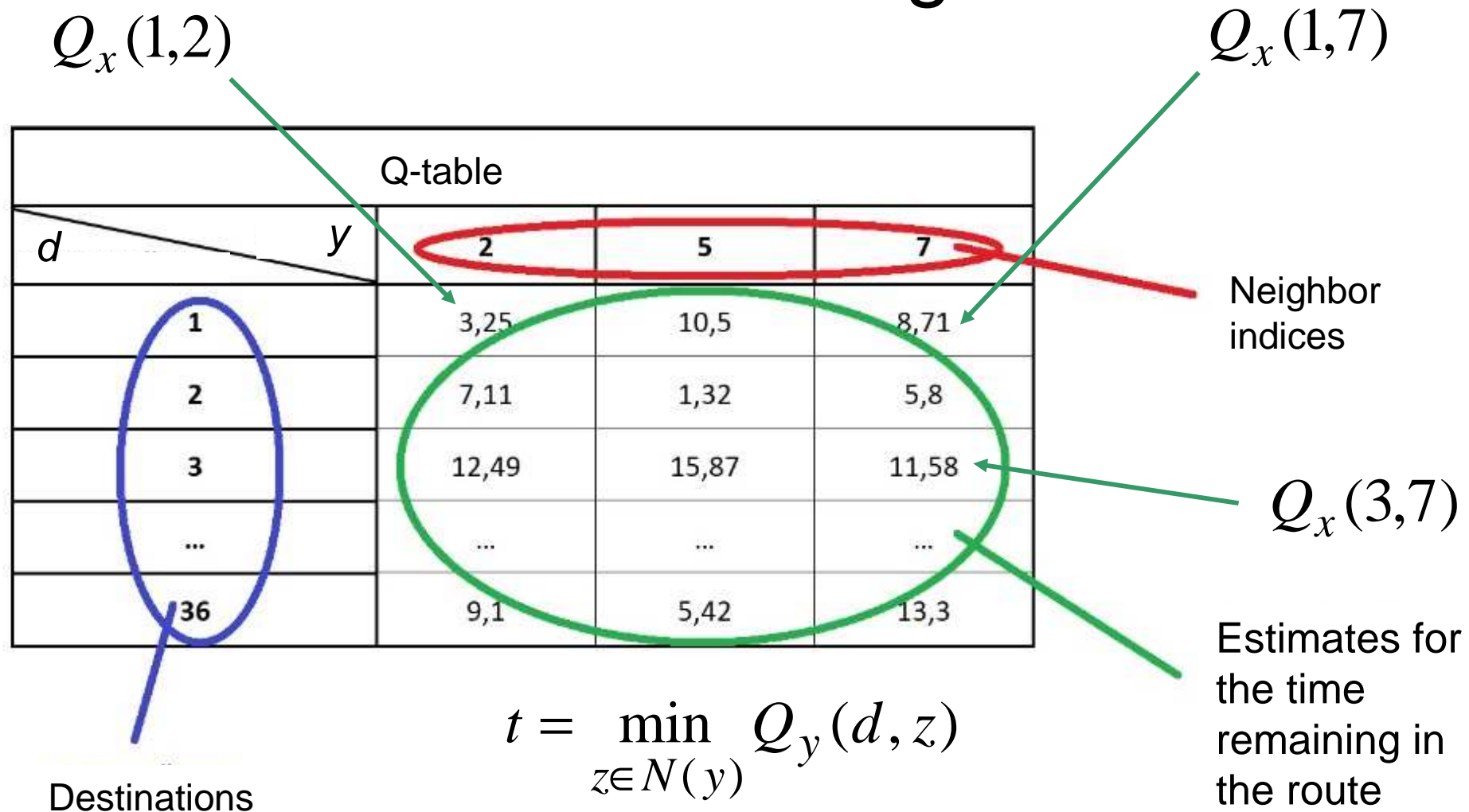
problem of **routing** packets to meet **real-time** requirements



Q-routing and its extensions:

- based on reinforcement learning
- flexible
- lightweight

Q-routing

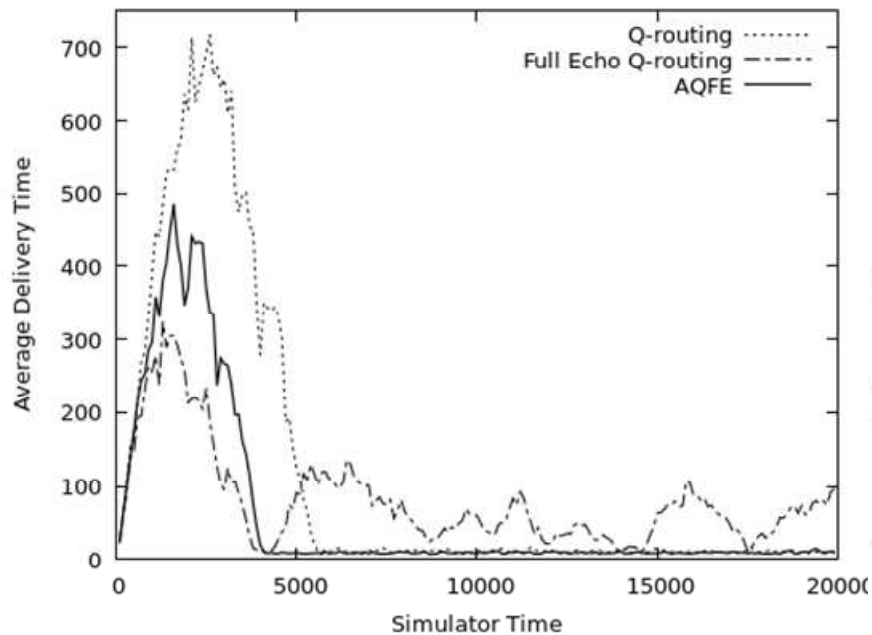


$$Q_x(d, y) = Q_x(d, y) + \eta \cdot (q + s + t - Q_x(d, y))$$

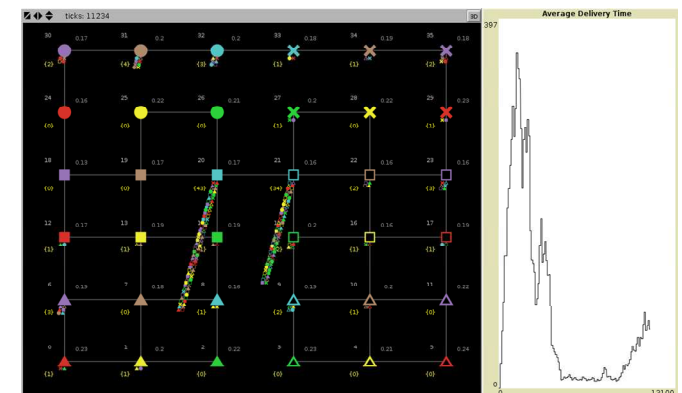
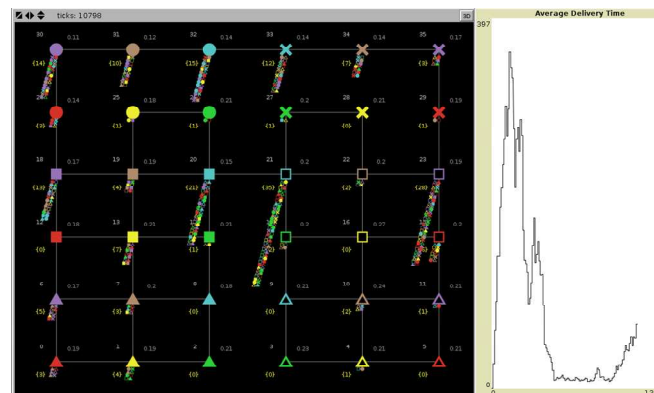
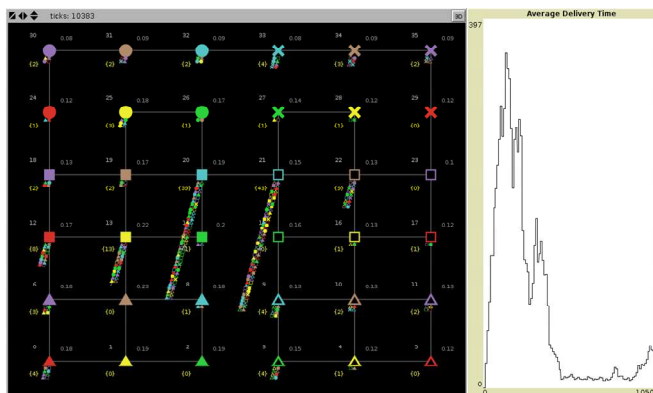
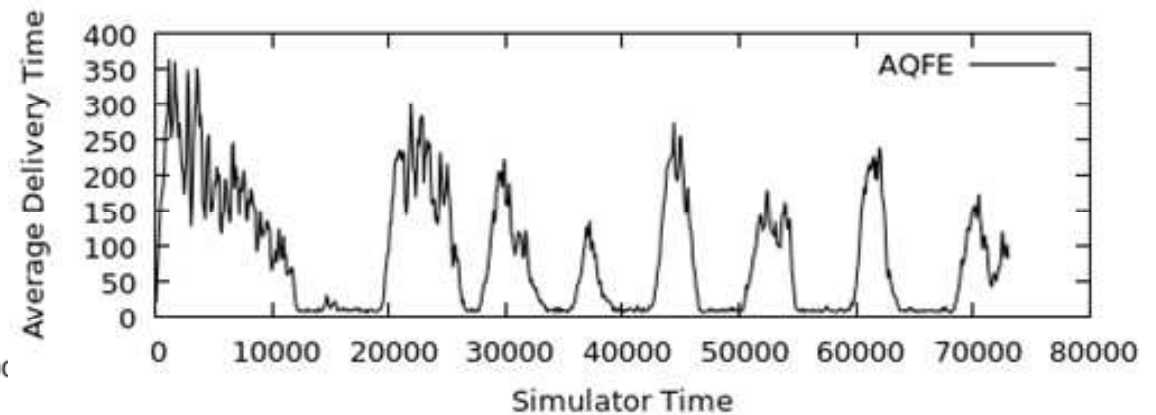
Extensions: Full Echo, DRQ-routing, AQFE etc

Unpredictability of Q-routing and its extensions

- initial learning spike (caused by changes, can be estimated)
- self-induced oscillations (problem to **predict** or **eliminate**)

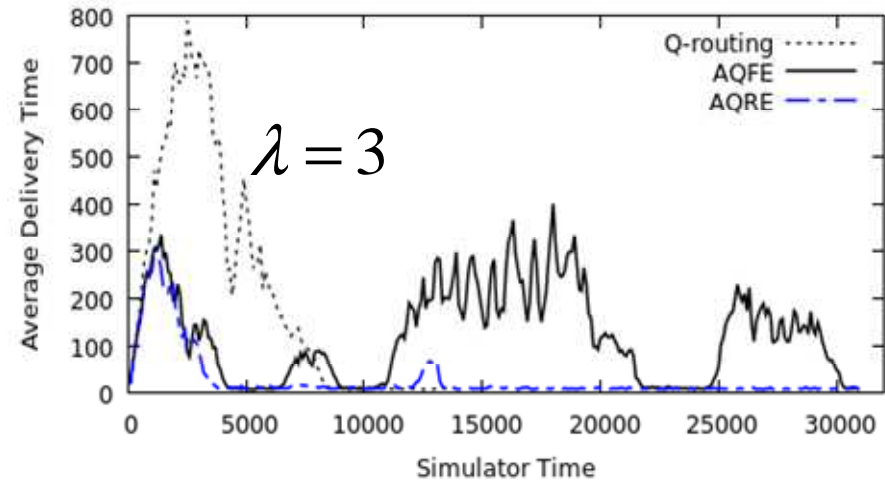


AQFE has smaller initial spike but oscillate under high load

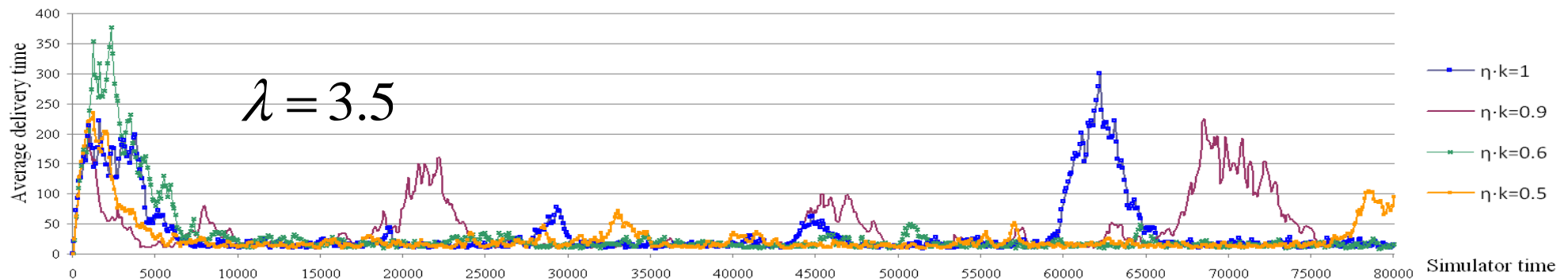


New extensions of Q-routing are proposed:

- (i) **AQRE** – Adaptive Q-routing with Random Echo
- (ii) **AQRERM** – AQRE with Route Memory



But under **higher load** spikes occur with some **regularity**. This can be used to predict and reduce spikes.



Performance of AQRERM under high load conditons for **stationary** network and various $\eta \cdot k$

We hypothesize that the spike indicates the start of some kind of **hyperperiod**.

Future research: find the methods to estimate the hyperperiods, prevent the spikes, stabilize end-to-end delays, reduce jitters, and further improve predictability under high loads.