Liveliness Evaluation of a Cooperation and Accounting Strategy in Hybrid Networks

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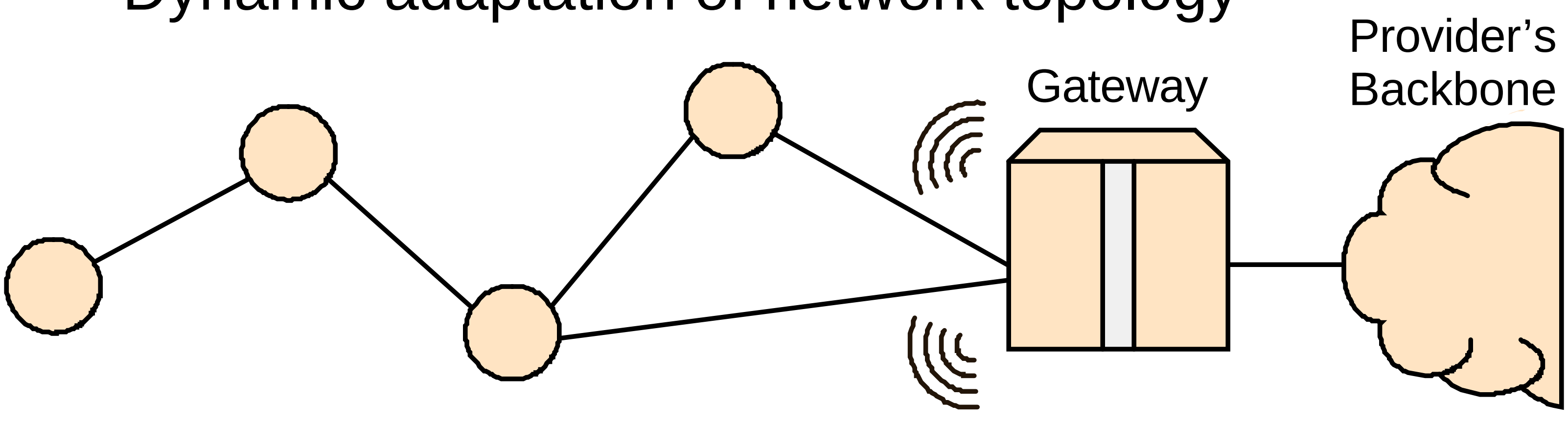
Introduction

- Multi-hop Cellular Networks
  - Combine dynamics of mobile ad hoc networks and reliability of infrastructured wireless networks
  - Compared to single-hop
    - Increased coverage area
    - Dynamic adaptation of network topology

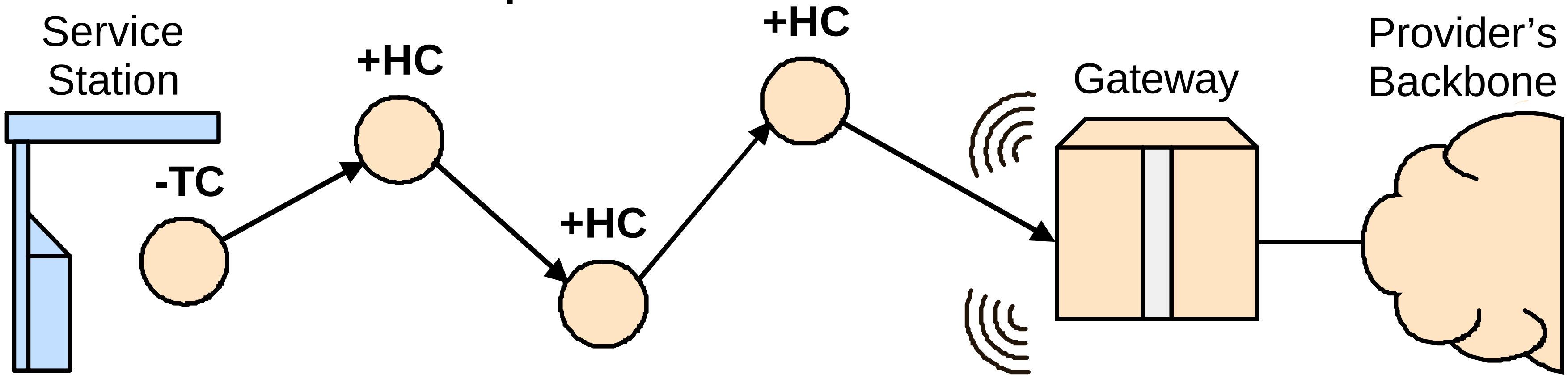


Motivation

- New context to deal with weaknesses of mobile ad hoc networks such as
  - Routing
  - Security
  - Cooperation
- Stimulate cooperation without threat of punishment
- Make cooperation a rewarding alternative to selfishness

CASHnet Concept

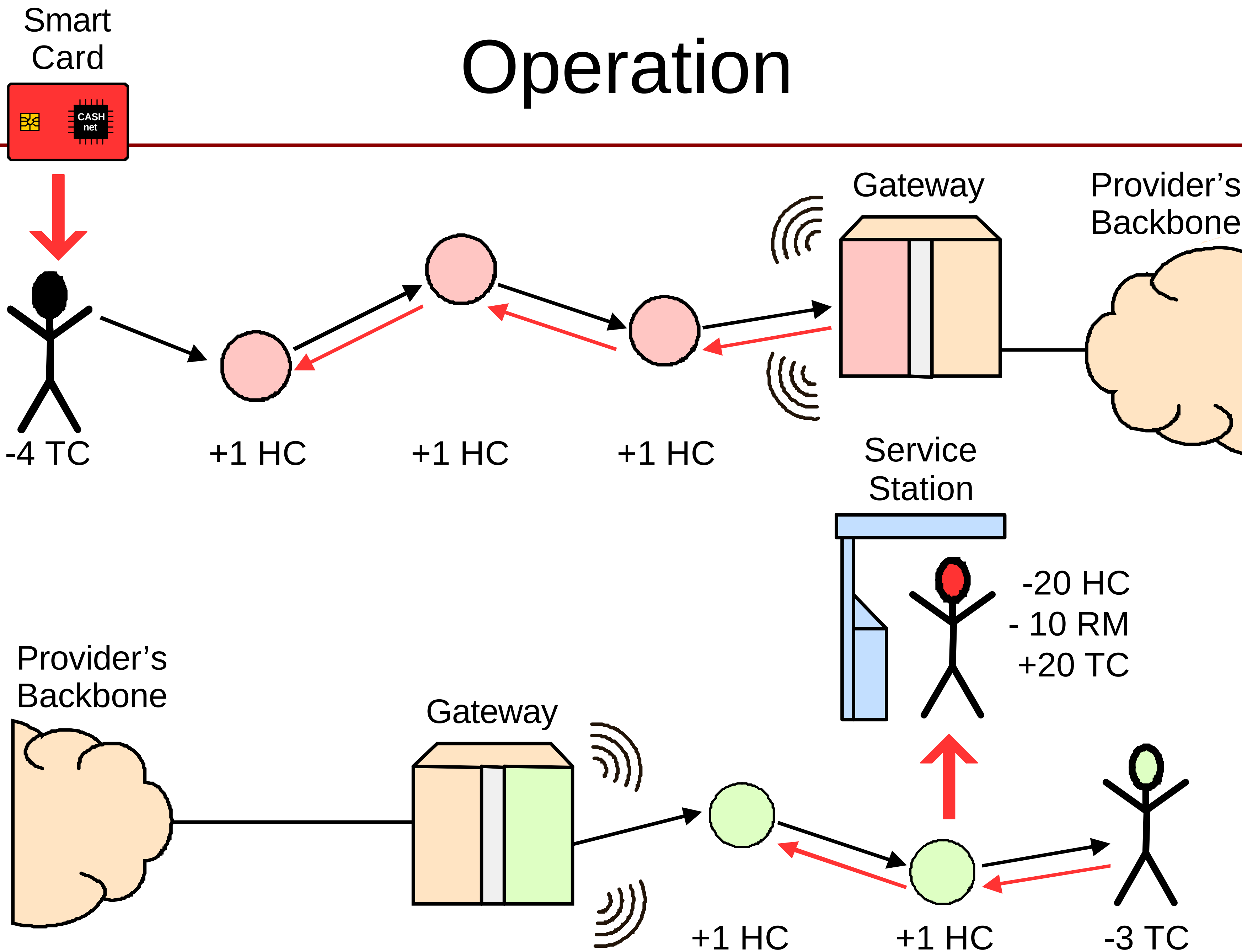
- Every time a node wants to transmit a self-generated packet, it has to pay with *Traffic Credits* (TC)
- Every time a node forwards a packet, it gets *Helper Credits* (HC)
- Traffic Credits can be bought for real money or traded for Helper Credits at service stations



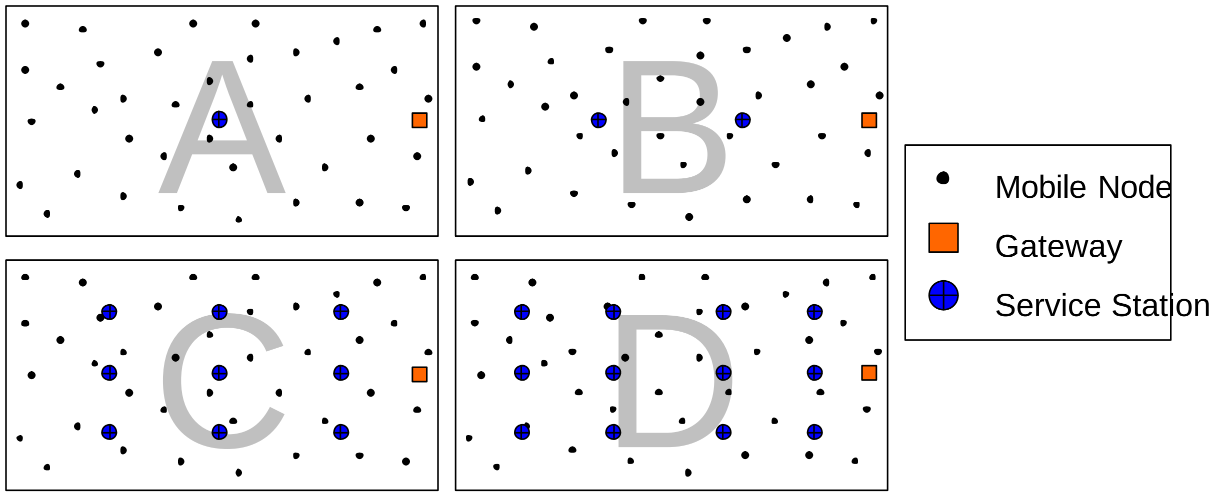
Architecture

- Assumptions
  - Tamper resistant device which allows safe execution of CASHnet functions and maintains two accounts
  - Distance (in hop counts) to gateway provided by routing protocol
  - Sufficient processing power on the node
- Security mechanisms are based on public key cryptography
  - Nodes authenticate themselves using certificates with short life time issued by the provider
  - Transmitted messages are digitally singed ensuring non-repudiation (data integrity and data origin authentication)

Operation


Smart
Card
CASH
net
-4 TC
+1 HC
+1 HC
+1 HC
Gateway
Provider's
Backbone
Service
Station
-20 HC
- 10 RM
+20 TC
Provider's
Backbone
Gateway
+1 HC
+1 HC
-3 TC

Simulation Scenarios

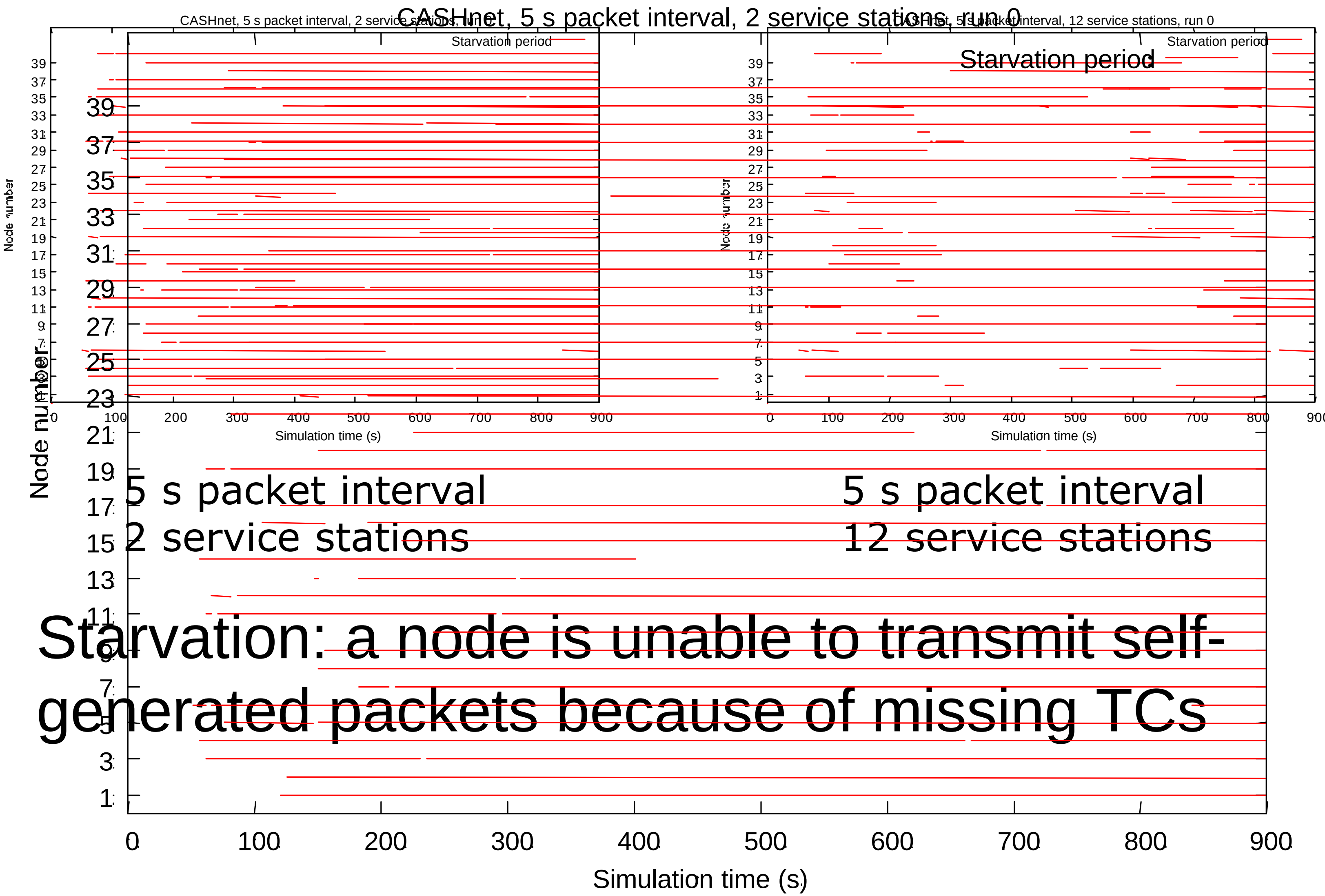


Parameter	Value
Initial Traffic Credits account state	100 TC
Initial Real Money account state	500
Traffic Helper Credits exchange rate	1:1
Exchange threshold at Service Stations	10 HC
Distance threshold to Service Stations	50 m

Simulation Parameters

Parameter	Value
Area	1500 m x 800 m
Number of nodes	40
Transmission range	250 m
Mobility model	random waypoint
Speed	u. d. between 1 and 10 m/s
Pause time	u. d. between 0 and 20 s
Packet generation rate	1, 0.2, 0.1 pkt/s
Number of Service Stations	1, 2, 9, 12
Simulation time	900 s

Starvation Periods

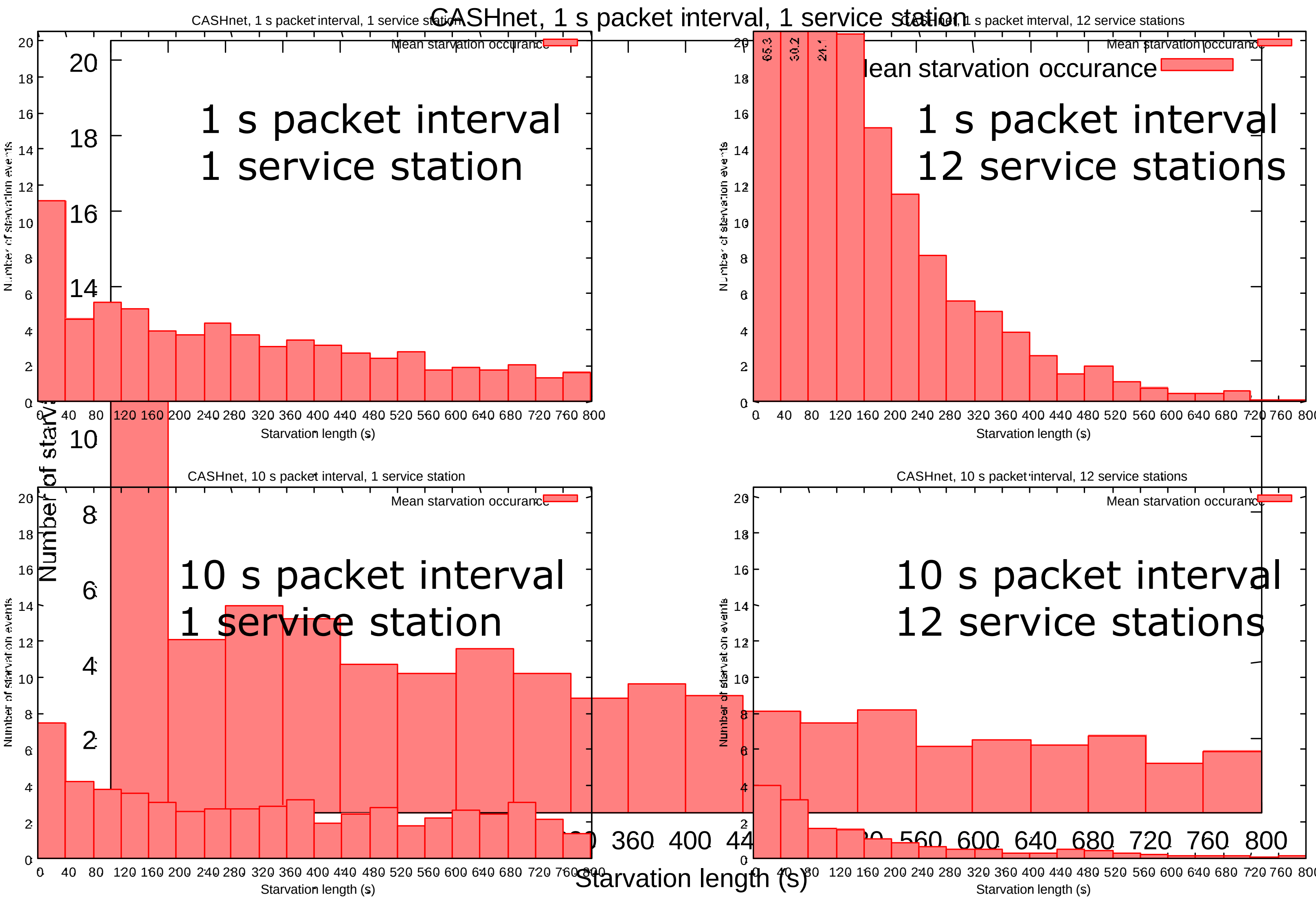


5 s packet interval
2 service stations

5 s packet interval
12 service stations

- Starvation: a node is unable to transmit self-generated packets because of missing TCs

Starvation Events/Duration Category



Results

- Duration and frequency of starvation events correlates with
  - Number of Service Stations
  - Location of Service Stations
- Simulation results affected by mobility model
  - Random waypoint movement paths behave centric (2 service stations worse than 1 centered)
- Per packet charging lets nodes run out of Traffic Credits/Real Money quickly

Summary & Outlook

- Highly decentralized accounting and security architecture
- Selfish nodes are allowed, but cooperation is encouraged via rewards
- Cost sharing between sender & receiver
- Evaluation of starvation property through simulations

- Compare with other cooperation schemes
- Use different mobility models, e.g. restricted random waypoint
- Study effects of possible extensions (e.g. charging for ad hoc only traffic, deposit payment for receiving traffic, increasing granularity)
- Specify charging/remuneration relation

Implementation

- ns-2 [Vint Project], Wireless and Mobility extensions [Rice] and AODV+ [Hamidian]
- Class CashnetNode inherits from MobileNode
- Agent at ns2 src/sink does rewarding
- Class CMUTrace extended for CASHnet events