Influence of Information Aging in Self Organizing Joint Radio Resource Management Systems

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Outline

- Motivation
- Scenario description
- Results
- Conclusion

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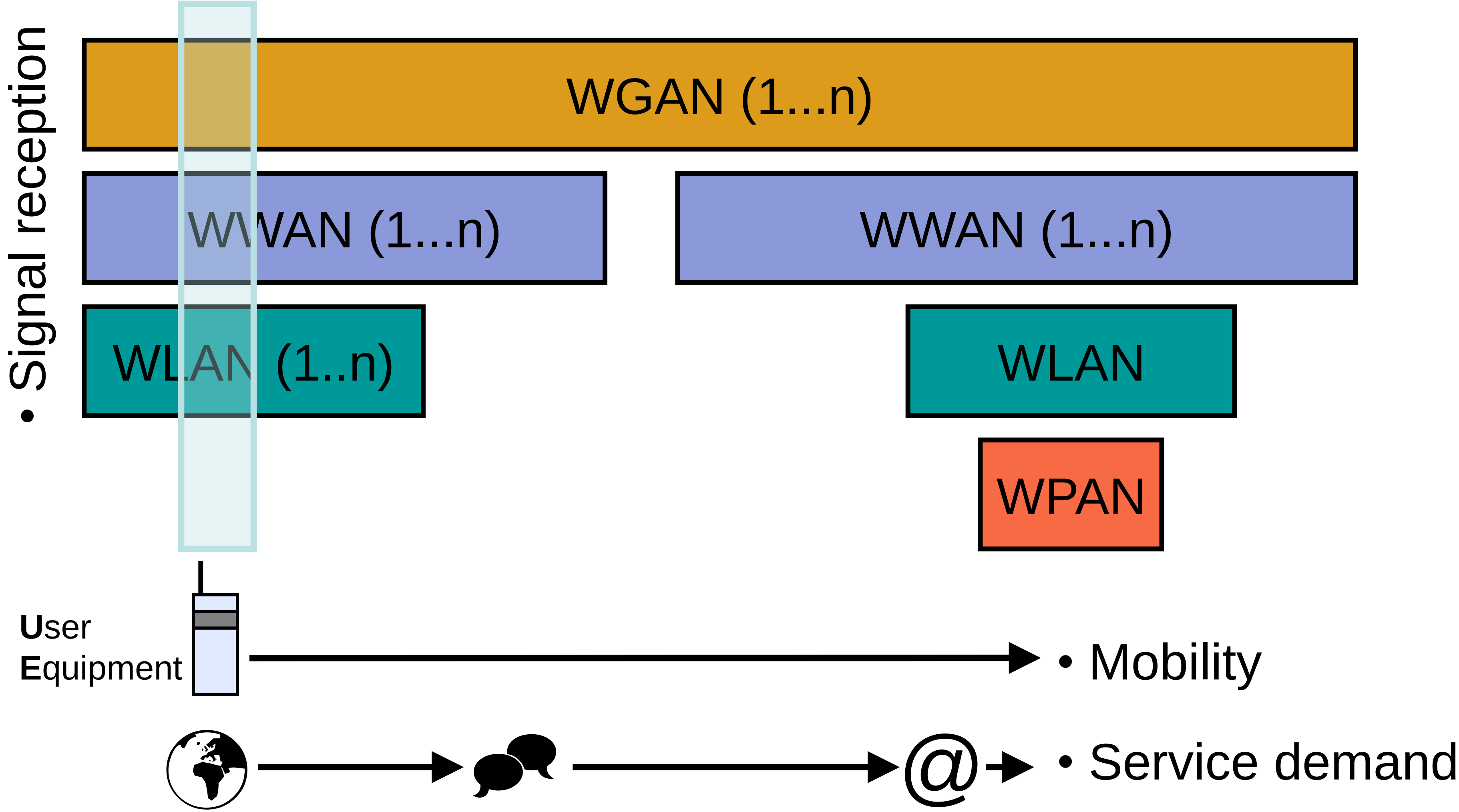
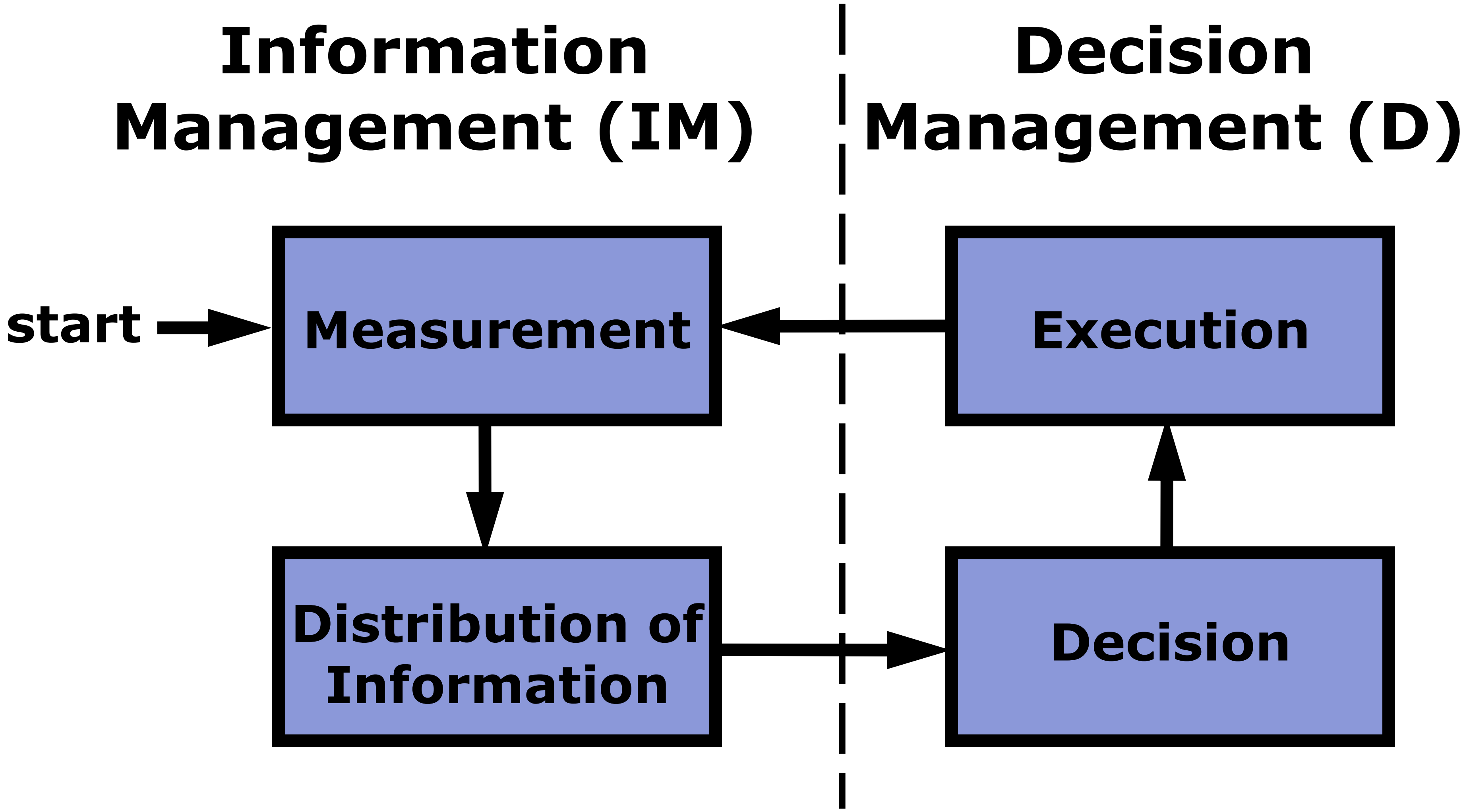
UE in a Changing Environment – Reason for JRRM



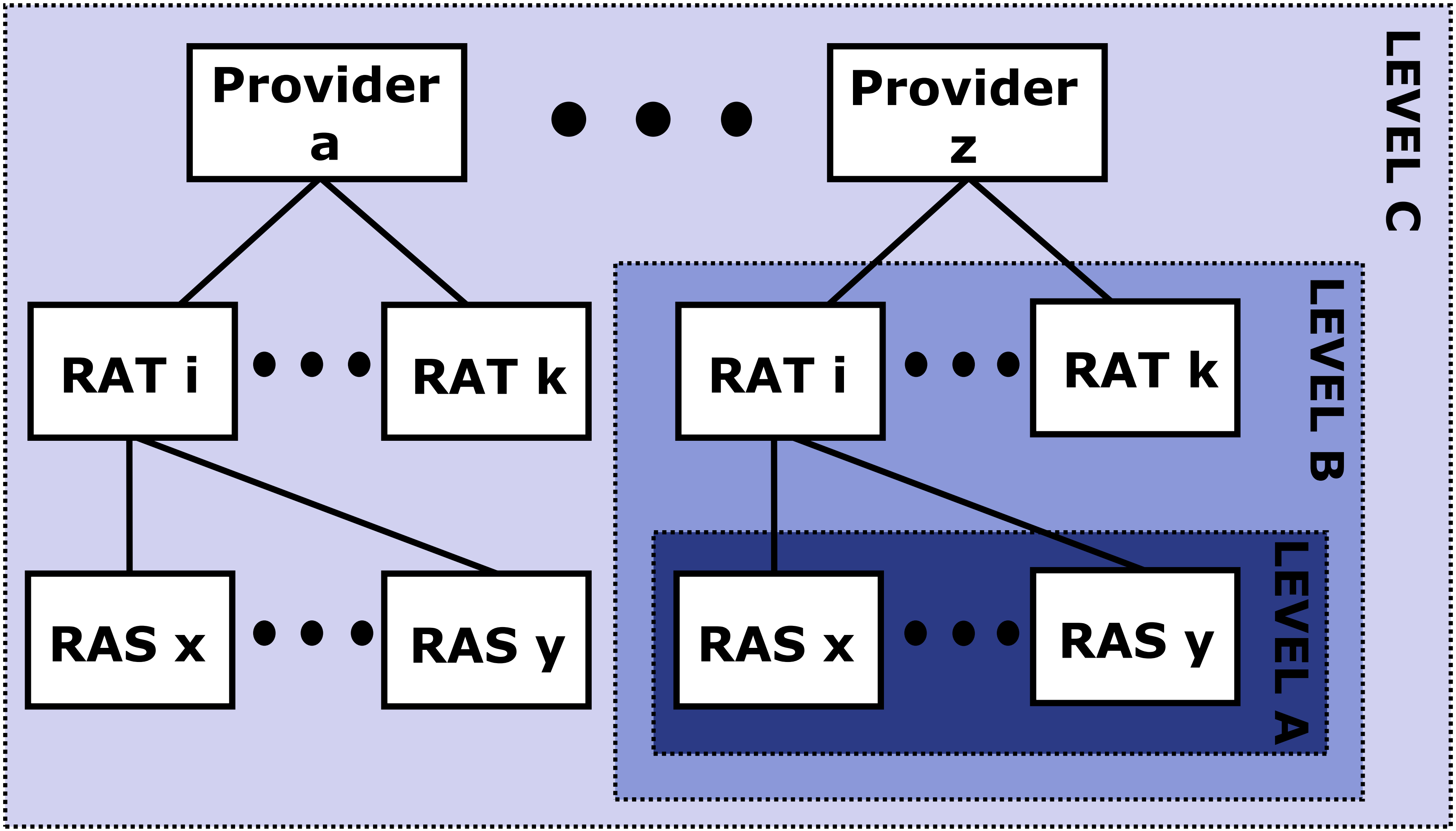
JRRM Control Loop



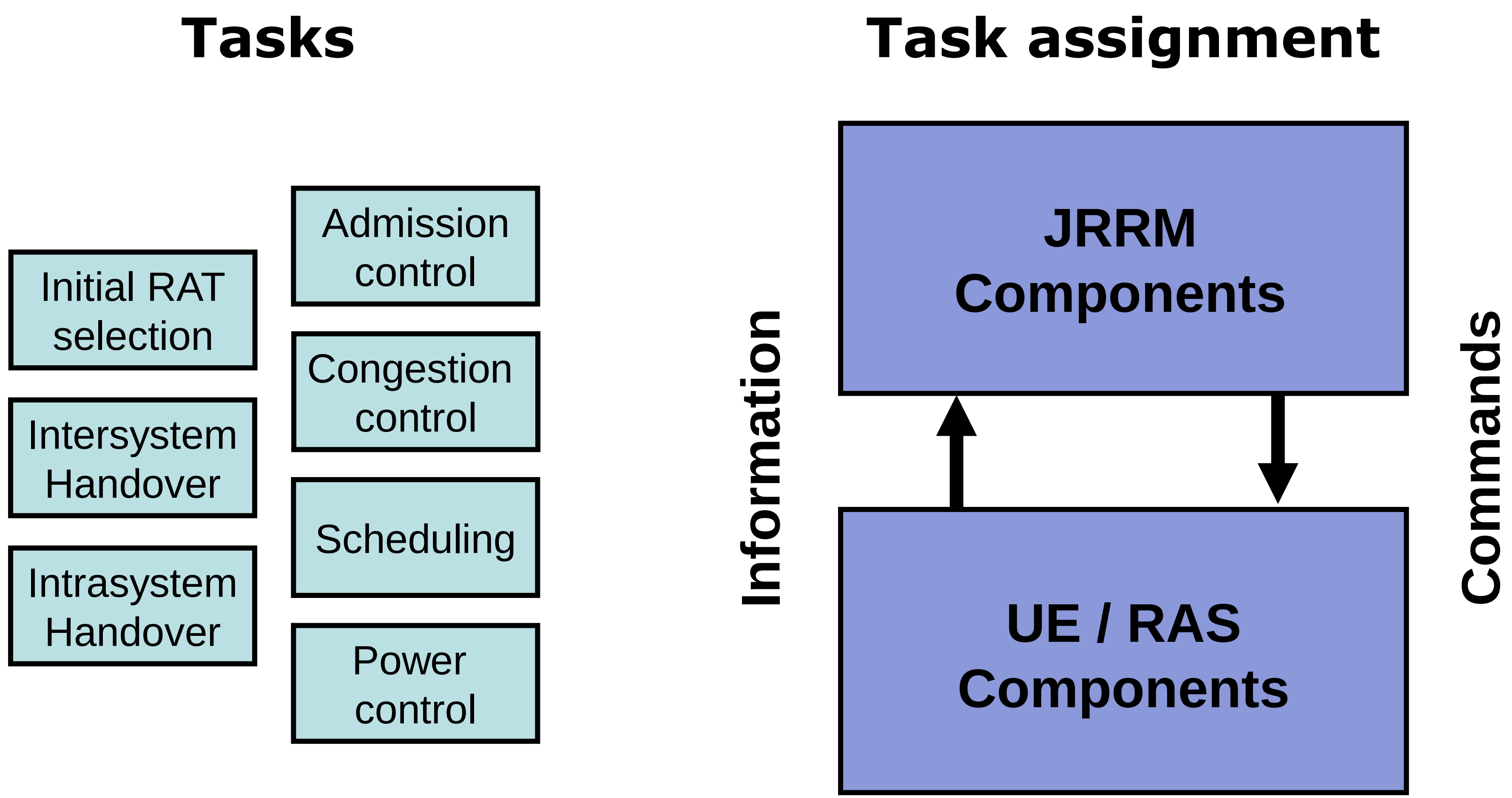
Causes for Information Aging

- **Information management**
  - Measurement times
  - Update intervals
  - Information transfer times
- **Decision management**
  - Evaluation times
  - Execution times
  - Command transfer times

Different JRRM System Boundary Levels



Different JRRM Integration Levels



Impact of Information Aging

- **Depends on speed and burstiness of system state change process**
- Observed/controlled parameter
  - General time horizon (ms vs. days)
- User behavior
  - Service demand (active sessions, service type)
  - Mobility (signal quality, interference, active sessions)
- System structure
  - cell layout (signal quality, interference, active sessions)

Subject of this Investigation

- **Influence of aged information on the quality of the JRRM solution.**
  - Sensitivity of JRRM algorithms
    - Different speed and burstiness of system state change process
- **Compare cost of system observation and control to algorithm performance**
  - Transfer times (**IM**)
  - Start load threshold (**ST**)
  - Target load threshold (**TT**)
  - Minimal load difference (**MLD**)

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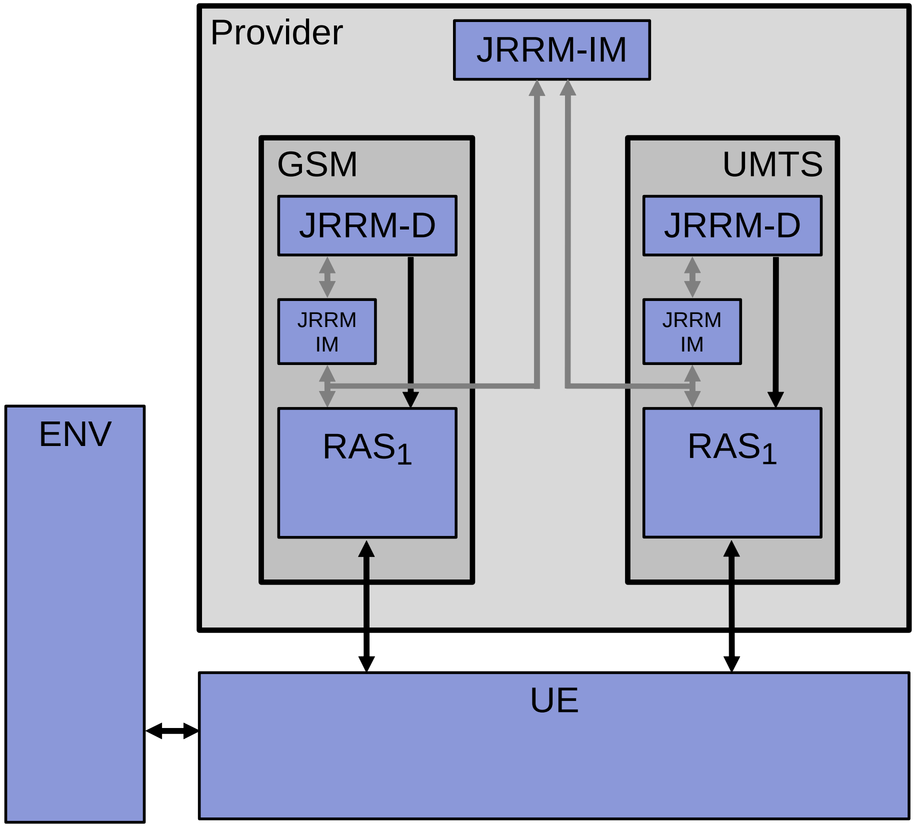
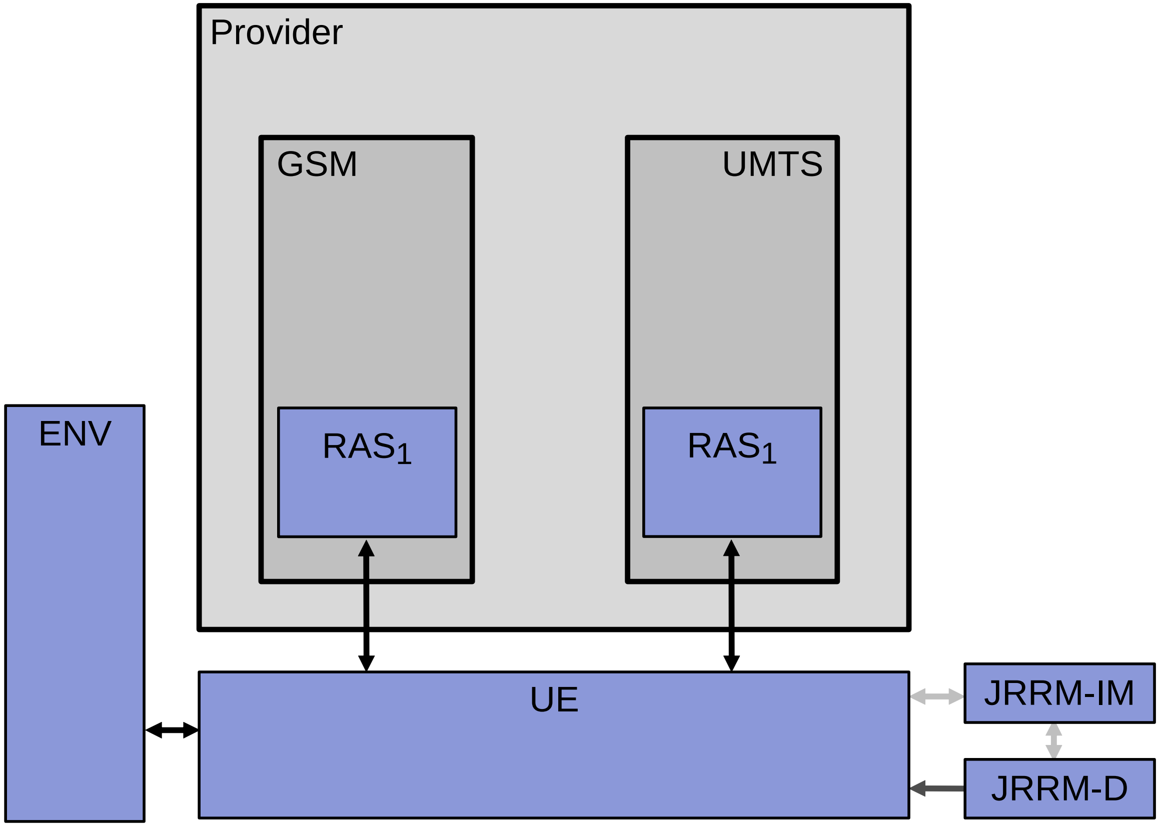
Scenario Layout (I)

- **Network initiated**, JRRM multiple RAT, low scale integration, decentralized decision



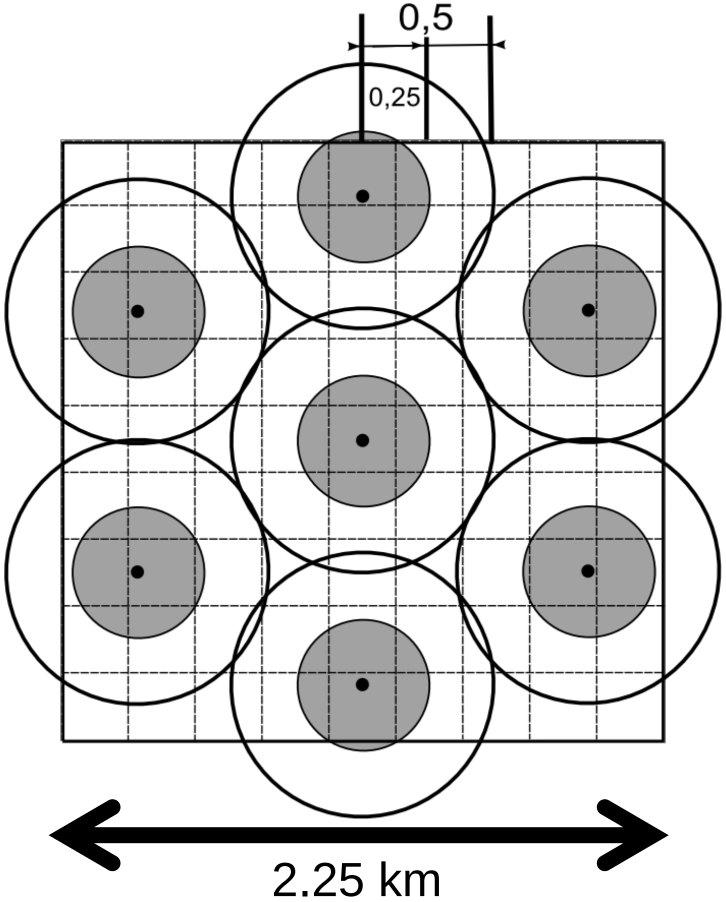
Scenario Layout (II)

- **Mobile initiated**, JRRM multiple RAT, low scale integration, decentralized decision



Scenario Layout (III)

- Seven co-located cells per RAS (diameter 1km)
- Good / moderate signal reception areas
- CS / PS channel
- CS connections preempt PS connections in GSM
- PS channel is shared in GPRS and is dedicated in UMTS



Scenario Service Parameters

- Conversational real time service (**CS**) and non real time web-service (**PS**)
- Different speeds of service state change process
  - Variation of service duration (**R**) and arrival rate (constant mean utilization)
  - Variation of moving speed (**v**) 1 m/s to 15 m/s
- Different burstiness of service state change process
  - Interarrival time distribution: $c_A = 1$ (**M**) and $c_A = 2$ ($\mathbf{H_2}$)

CS – conversational	PS – web-service
■ 10 to 40 calls/h per user (exp) ■ 300 user ■ 3 min to 0.75 min call duration (exp) ■ 150 Erlang ■ 12,2 kbit/s	■ 24 sessions/h per user ■ 200 user ■ Mean session size 60 kbyte (geo) ■ Mean page size 12 kbyte (geo) ■ Mean packet length 900 byte (const) ■ Reading time 30 s (exp) ■ 12-128 kbit/s (exp)

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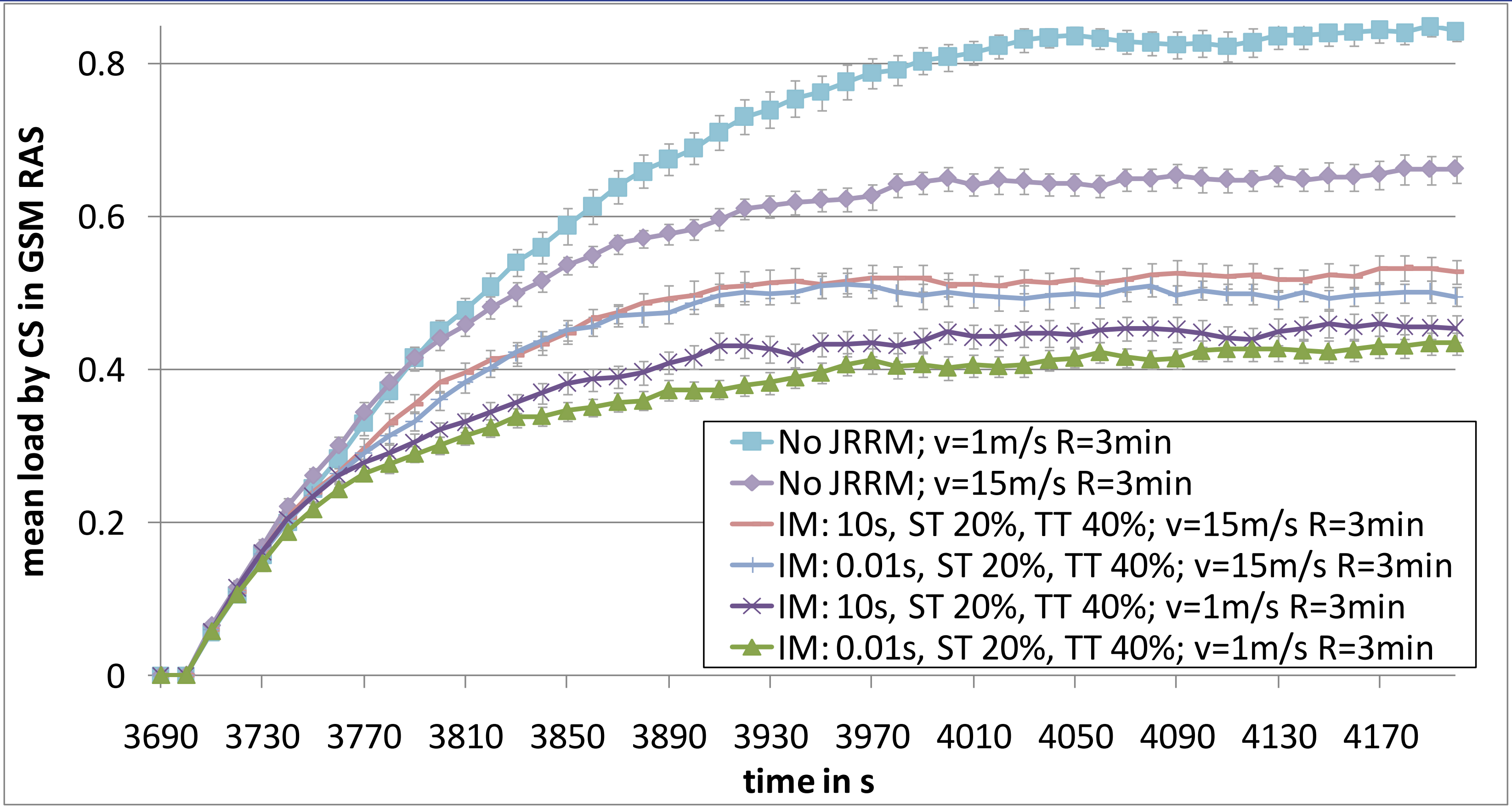
Results for Deactivated JRRM

Scenarios No JRRM	Blocking in % [±95%]		Dropping in % [±95%]		E[Datarate] in kbit/s
	PS	CS	PS	CS	PS
v=1, only PS, M	0.01 [0.01]	-	0.28 [0.05]	-	99,977 [285]
v=1, R=3, M	0.93 [0.06]	10.3 [0.8]	23.6 [0.7]	2.99 [0.22]	92,692 [409]
v=1, R=0.75, M	1.13 [0.06]	13.8 [0.4]	28.5 [0.7]	0.85 [0.06]	90,612 [346]
v=15, R=3, M	0.86 [0.05]	4.63 [0.26]	21.6 [0.4]	28.3 [0.98]	85,904 [591]
v=15, R=0.75, M	1.17 [0.05]	9.38 [0.30]	29.0 [0.6]	12.6 [0.31]	82,952 [534]
v=1, R=0.75, H_2	2.28 [0.15]	15.5 [1.0]	26.1 [0.9]	0.79 [0.07]	88,460 [488]
v=15, R=0.75, H_2	1.88 [0.11]	11.0 [0.3]	28.3 [1.0]	12.1 [0.49]	80,724 [926]

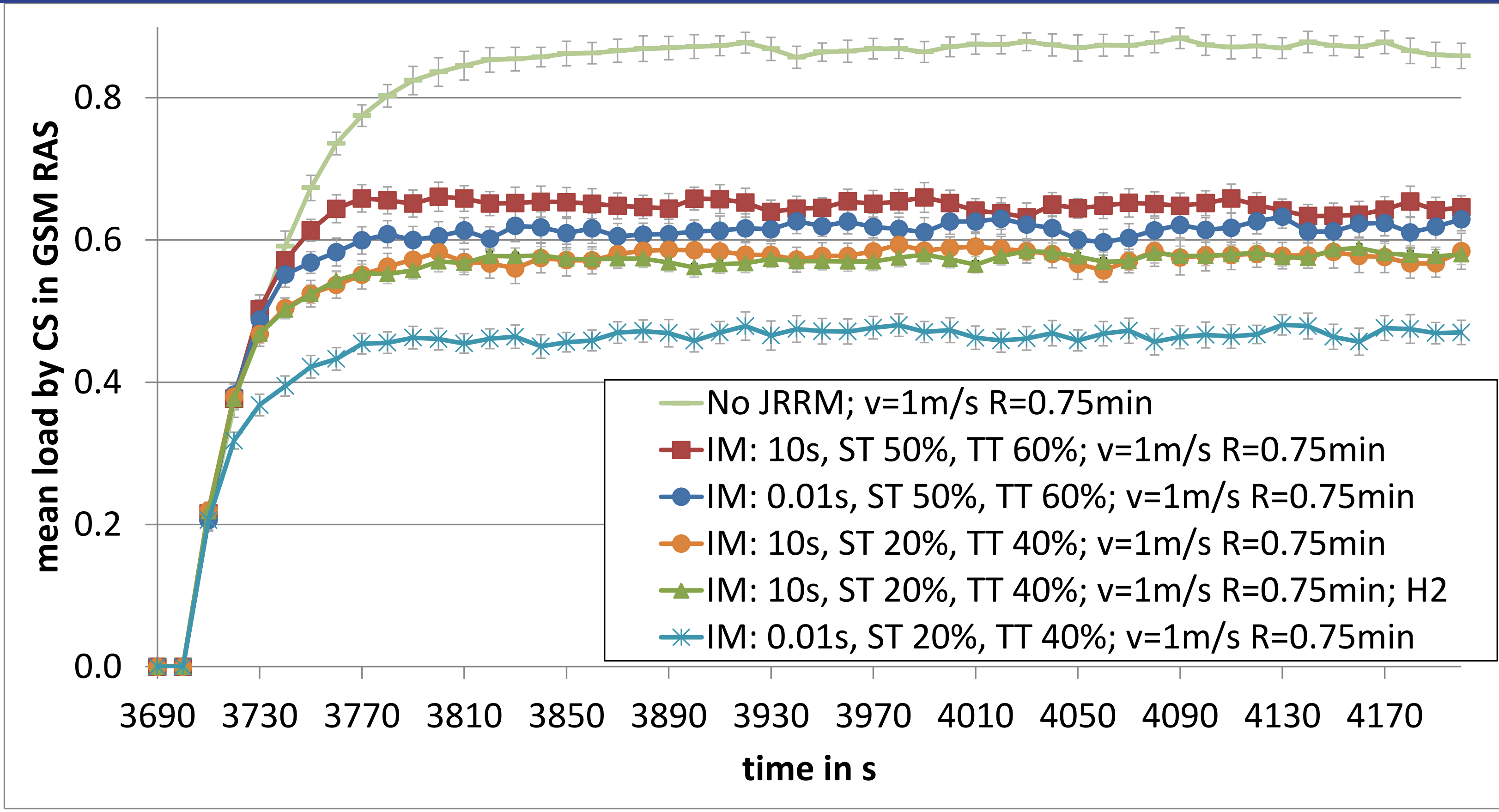
- Shared channel (EGPRS) has enough capacity for user demand
- EGPRS is impaired by CS background traffic
  - Conversational services are displacing web services
- Higher system dynamics lead to worse performance values
  - Interdependency of utilization, blocking, dropping and movement

Transient Simulation Results: Mean CS Load in GSM



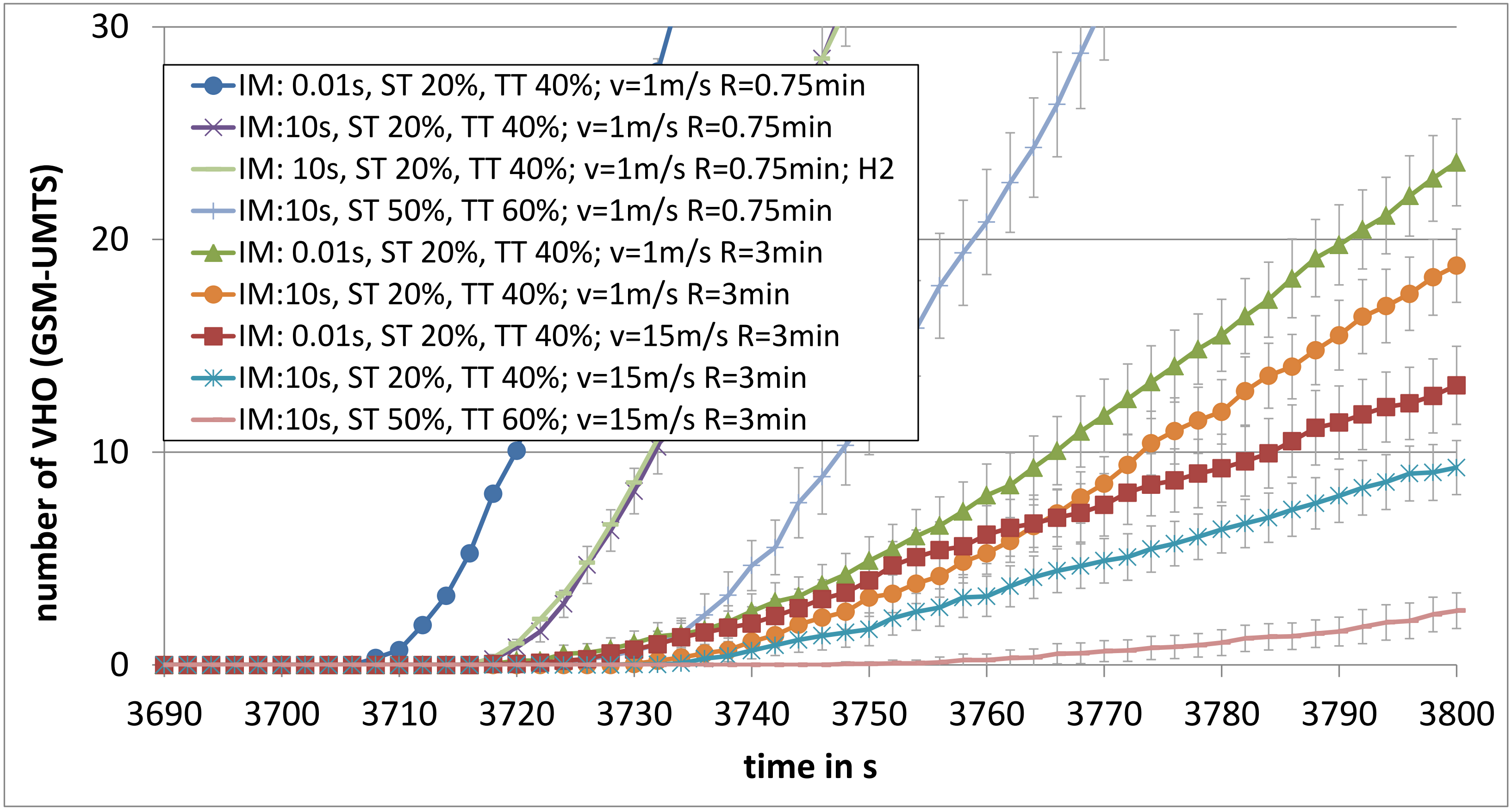
- Higher moving speeds (**v**) lead to lower mean utilizations (no HO reserve)
- Higher moving speeds decrease the ability to maintain the target load
  - UE already blocked or dropped; Vertical handover pointing to unavailable cells
- Faster JRRM (**IM**) is better in maintaining the target load

Transient Simulation Results: Mean CS Load in GSM



- Fast arrival and departure process (**R**) leads to a worse JRRM performance
  - It is more difficult to maintain lower target loads
- Time delay of **IM** has a bigger influence
  - commands for already terminated sessions

Transient Simulation Results: Number of Vertical HO

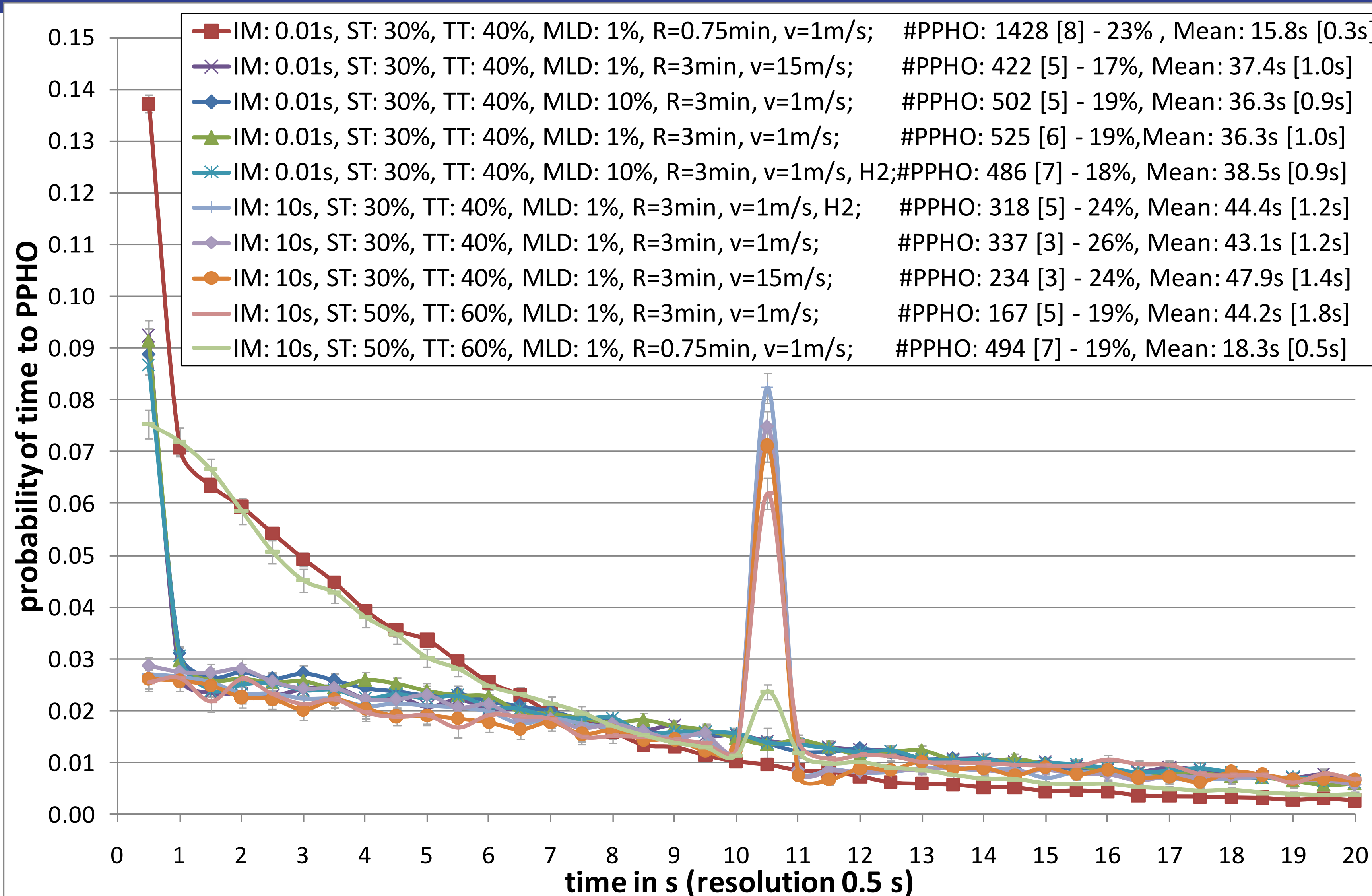


- **ST, TT, R, v, (IM):** influence on number of VHO
- High moving speeds (**v**): some UE already blocked or dropped; lower cell utilization
- **ST, TT, IM, (R):** influence on time of execution - delayed reaction

Simulation Results: PDF of PPHO (I)

- **R** and **IM** have the biggest influence on the shape of pdf for Ping Pong Handover (PPHO)
- **R** has a big and **IM** a moderate influence on the mean time between PPHO
- Higher **ST/TT** values reduce the mean number of PPHO
- $\mathbf{H_2}$ arrival distribution reduces the mean number of PPHO and increases the mean time between PPHO
- The min load difference (**MLD**) has a slight effect on the mean number of PPHO

Simulation Results: PDF of PPHO (II)



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Conclusion

- More up-to-date system state information lead to a better QoS but cause higher costs
  - Measurement (ST, TT, IM, MLD)
  - Command transfer and execution
  - Ping-pong-handover
- Less up-to-date system state information lead to increased costs for session handling issues (blocking, dropping)
- Highest impact: service arrival/duration and velocity
  - Distribution of arrival process has only a small effect on costs of IM
    - Nevertheless achieved QoS is different
- JRRM algorithms need to adapt their response times to the dynamic of the controlled processes
  - Problems with direct control of sessions if IM is slow

End of Presentation

Thank you very much for your attention!

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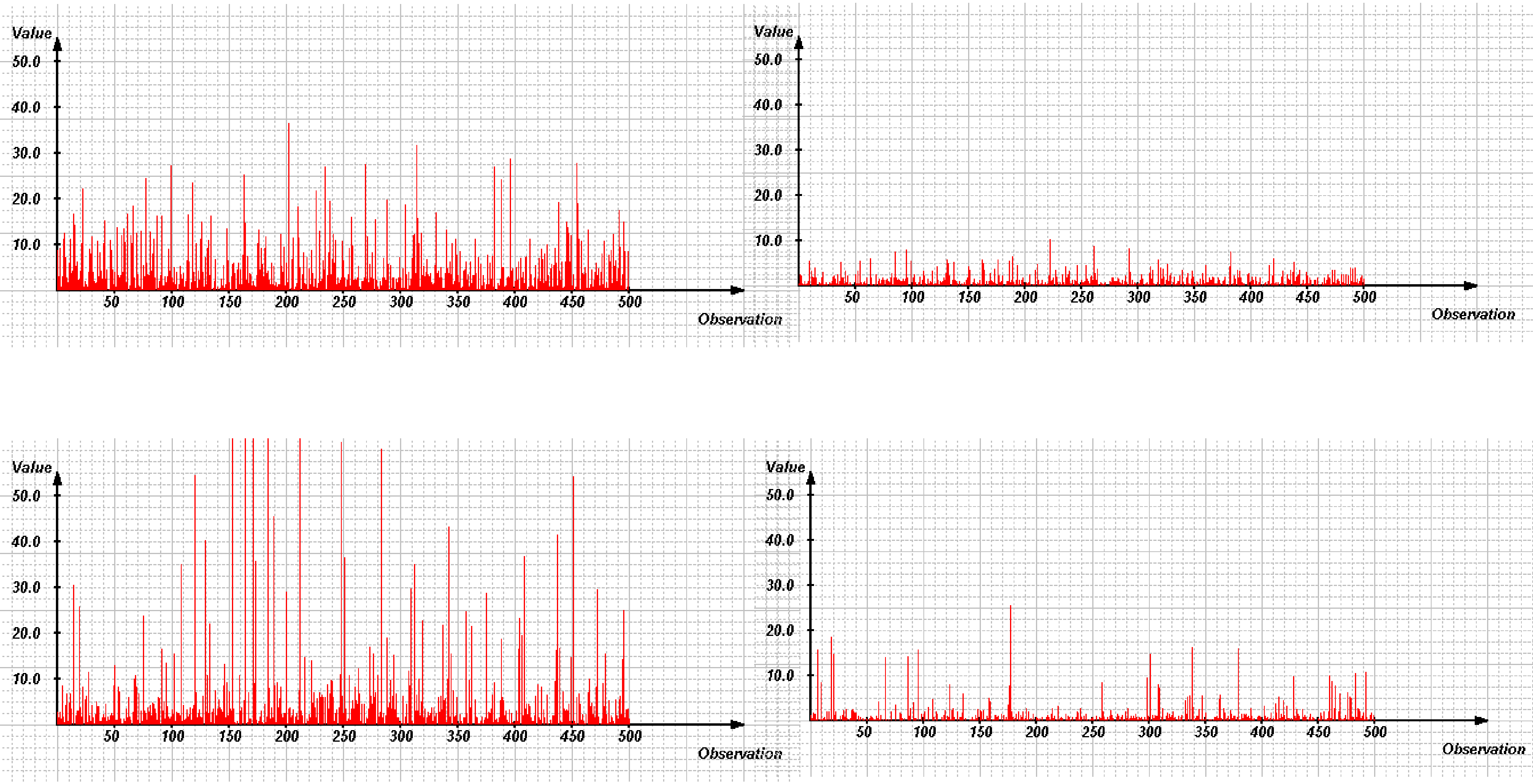
Overall Results: MKP (PS only EGPRS)

Scenarios	Blocking in % [±95%]		Dropping in %		E[Datarate] in kbit/s
	PS	CS	PS	CS	PS
IM: 10s, ST 20%, TT 40%, v=1m/s, R=3min	0.01 [0.01]	0.01 [0.01]	0.69 [0.10]	0.00 [0.01]	99,264 [335]
IM: 10s, ST 50%, TT 60%, v=1m/s, R=3min	0.04 [0.01]	0.14 [0.05]	2.36 [0.25]	0.04 [0.02]	97,645 [287]
IM: 10s, ST 50%, TT 60%, v=1m/s, R=0.75min	0.24 [0.03]	1.03 [0.08]	8.87 [0.31]	0.05 [0.01]	93,980 [275]
IM: 0.01s, ST 50%, TT 60%, v=1m/s, R=0.75min	0.10 [0.02]	0.36 [0.05]	4.84 [0.26]	0.02 [0.01]	95,668 [265]
IM: 10s, ST 20%, TT 40%, v=1m/s, R=0.75min	0.14 [0.02]	0.75 [0.10]	6.21 [0.43]	0.02 [0.01]	95,918 [381]
IM: 0.01s, ST 20%, TT 40%, v=1m/s, R=0.75min	0.03 [0.01]	0.14 [0.03]	1.45 [0.17]	0.00 [0.00]	99,195 [265]
IM: 0.01s, ST 20%, TT 40%, v=1m/s, R=0.75min, H_2	0.07 [0.01]	0.25 [0,04]	2.33 [0.22]	0.01 [0.01]	96,389 [442]
IM: 10s, ST 20%, TT 40%, v=1m/s, R=0.75min, H_2	0.32 [0.04]	1.17 [0.12]	7.15 [0.54]	0.04 [0.01]	93,761 [414]
IM: 0.01s, ST 20%, TT 40%, v=15m/s, R=0.75min	0.53 [0.04]	2.22 [0.12]	16.1 [0.4]	2.94 [0.14]	87,571 [478]
IM: 10s, ST 50%, TT 60%, v=15m/s, R=3min	0.73 [0.05]	3.69 [0.25]	18.9 [0.4]	19.5 [0.8]	87,425 [581]

Scenarios	Prob. of VHO %	E[Costs] per session		E[Costs] of RAS meas.
	CS	PS	CS	RAS
IM: 10s, ST 20%, TT 40%, v=1m/s, R=3min	52.59 [1.07]	591 [6]	172.0 [4.16]	2,074,256 [9,037]
IM: 10s, ST 50%, TT 60%, v=1m/s, R=3min	39.93 [1.14]	591 [6]	210.2 [3.58]	877,473 [6,793]
IM: 10s, ST 50%, TT 60%, v=1m/s, R=0.75min	35.19 [0.58]	577 [5]	53.23 [0.57]	853,035 [5,593]
IM: 0.01s, ST 50%, TT 60%, v=1m/s, R=0.75min	38.93 [0.62]	583 [5]	50.05 [0.43]	996,900 [6,032]
IM: 10s, ST 20%, TT 40%, v=1m/s, R=0.75min	42.95 [0.63]	582 [5]	47.36 [0.56]	2,146,827 [8,762]
IM: 0.01s, ST 20%, TT 40%, v=1m/s, R=0.75min	53.55 [0.67]	588 [6]	39.20 [0.48]	2,163,771 [8,787]
IM: 0.01s, ST 20%, TT 40%, v=1m/s, R=0.75min, H_2	53.25 [1.76]	589 [9]	39.17 [1.03]	2,146,669 [13,422]
IM: 10s, ST 20%, TT 40%, v=1m/s, R=0.75min, H_2	42.50 [1.03]	582 [9]	47.18 [0.91]	2,130,221 [14,775]
IM: 0.01s, ST 20%, TT 40%, v=15m/s, R=0.75min	37.80 [0.51]	566 [6]	49.45 [0.55]	2,096,565 [8,877]
IM: 10s, ST 50%, TT 60%, v=15m/s, R=3min	16.28 [0.82]	559 [5]	214.5 [3.98]	882,229 [6,420]

H_2 vs. M - Distribution

6 min | 1.5 min



Simulation Framework – Overview

- **Model framework**
  - Five components (**ENV, UE, RAS, JRRM-IM, JRRM-D**)
  - Supports a wide variety of JRRM scenarios (JRRM structures & integration levels)
  - **Supports JRRM control loop and cost-benefit analysis**
- **Simulator HEKATE**
  - **Discrete event simulator** based on OMNeT++
  - **Hybrid simulation model**
    - Flow level of connections is modeled via discrete event simulation
    - Packet arrival/service process and resource consumption/utilization is considered via analytical models