Slicing in 5G networks

Update 16/10/2020

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A slice simulator with MDP resolution

Last Call

- Batch Manager
- Switch to absolute policy (before was in delta format)
- Support for N allocation policy (as thesis)
- Bugfix “in the timeslot I see the jobs arrived up to the previous instant” (before was “I see the jobs arrived until the last moment of this timeslot”)

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What's new?

- Slurm first usage
- Support for Bayati's assumptions
- Support for multi-slice (WIP)

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Formulation - Assumption

Delayed Action (timeslot view):

1. State
2. Action chosen according to the state
3. Arrival phase (losses)
4. Processing phase
5. Execution of the action chosen in (2)

Immediate Action (timeslot view):

1. State
2. Action chosen according to the state
3. Execution of the action chosen in (2)
4. Arrival phase (losses)
5. Processing phase

[NEW] Delayed Action + phases exchange (timeslot view):

1. State
2. Action chosen according to the state
3. Processing phase
4. Arrival phase (losses)
5. Execution of the action chosen in (2)

[NEW] Immediate Action + phases exchange (timeslot view):

1. State
2. Action chosen according to the state
3. Execution of the action chosen in (2)
4. Processing phase
5. Arrival phase (losses)

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Formulation - Modelling

Fill the queue with incoming jobs and then processing of the queue

$$Q(m, s \to m', s') = \sum_{a=[m'-m]^+}^{\text{qsize}-m} P(\text{arr} = a) \cdot P(\text{proc} = m + a - m' | a + m) \tag{2}$$

$$+ \sum_{a=\text{qsize}-m+1}^{\infty} P(\text{arr} = a) P(\text{proc} = \text{qsize} - m' | \text{qsize}) \tag{3}$$

Processing of the queue and then fill the queue with incoming jobs

$$Q(m, s \to m', s') = \sum_{a=[m'-m]^+}^{\text{qsize}-m} P(\text{arr} = a) \cdot P(\text{proc} = m + a - m' | m) \tag{4}$$

$$+ \sum_{a=\text{qsize}-m+1}^{\infty} P(\text{arr} = a) P(\text{proc} = \text{qsize} - m' | \text{qsize}) \tag{5}$$

Where $s' = action$ = [0-N] allocated servers

Delayed Action

$$P(\text{proc} = x|y) = \begin{cases} H^{s}_{\text{departures}}(x) & \text{if } x < y \\ \sum_{x=y}^{\infty} H^{s}_{\text{departures}}(x) & if = y \\ 0 & \text{otherwise} \end{cases}$$

Immediate Action

$$P(\text{proc} = x|y) = \begin{cases} H^{s'}_{\text{departures}}(x) & \text{if } x < y \\ \sum_{x=y}^{\infty} H^{s'}_{\text{departures}}(x) & if x = y \\ 0 & \text{otherwise} \end{cases}$$

Notice that is the number of current servers s is equal to 0, then the departure histogram will be just $\Delta_1([1., 0., ..., 0.])$

The transition probability is then:

$$Q^{\text{action}}(m, s \to m', s') = \begin{cases} Q(m, s \to m', s') & \text{if } s' = \text{action} \\ 0 & \text{otherwise} \end{cases} \tag{6}$$

Simulation Results

Common Parameters

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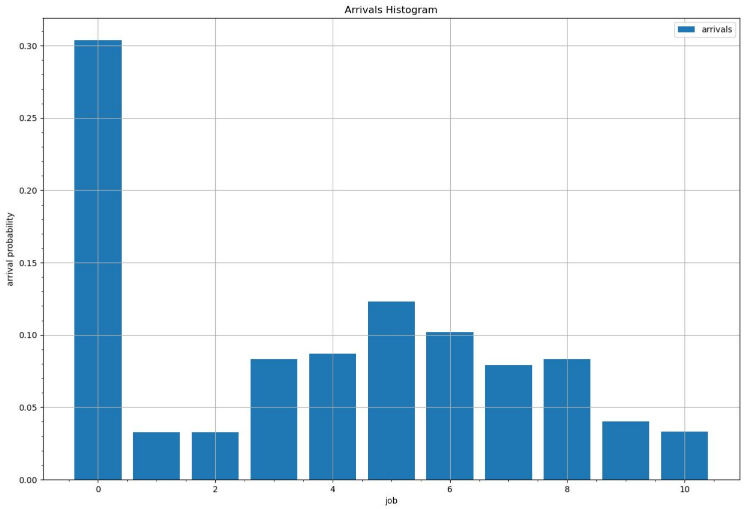
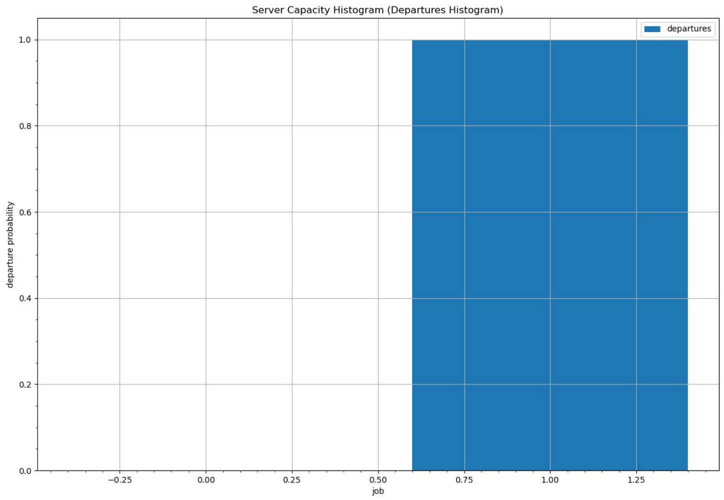
Simulation Results - Common Parameters





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Simulation Results - Common Parameters

- Queue size: 10
- Max allocated servers: 10
- C_j: 1; alpha: 1
- C_s: 1; beta: 1
- C_l: 1; gamma: 1
- Number of simulations: 5
- Simulation Time: 10k time slots
- MDP discount value: 0.99

Scenario 1

Delayed Action :
Default Assumptions VS Bayati's Assumptions

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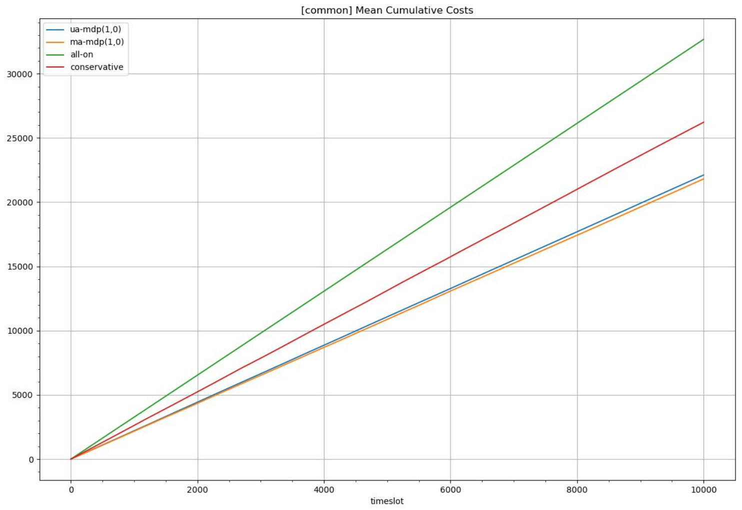
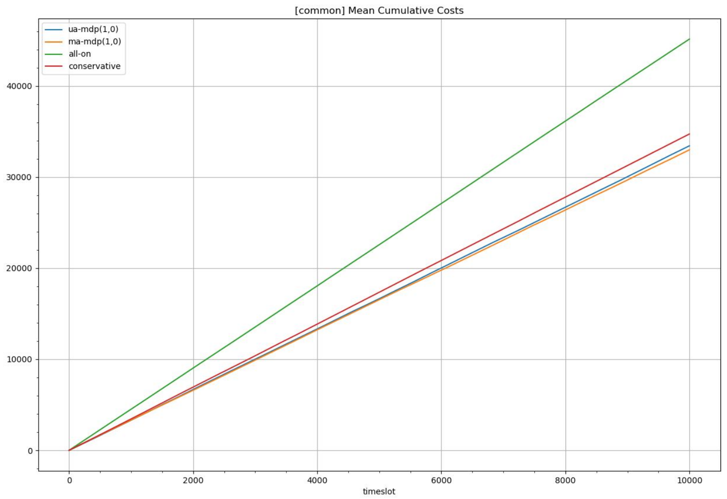
Scenario 1: Delayed Action + Default Assumptions VS Bayati’s Assumptions

Default Assumptions



Bayati’s Assumptions



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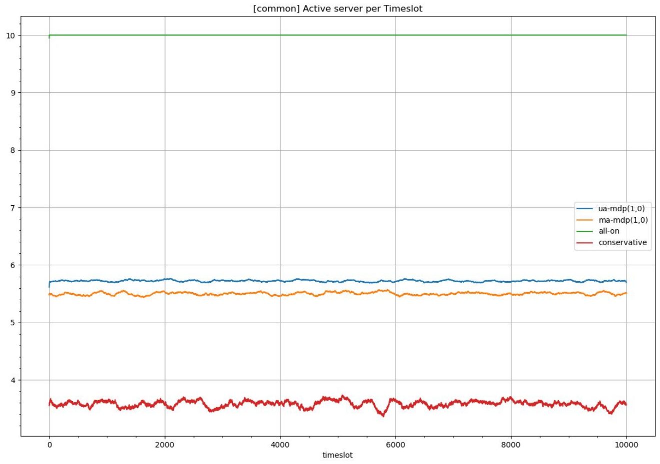
Scenario 1: Delayed Action + Default Assumptions VS Bayati's Assumptions

Default Assumptions



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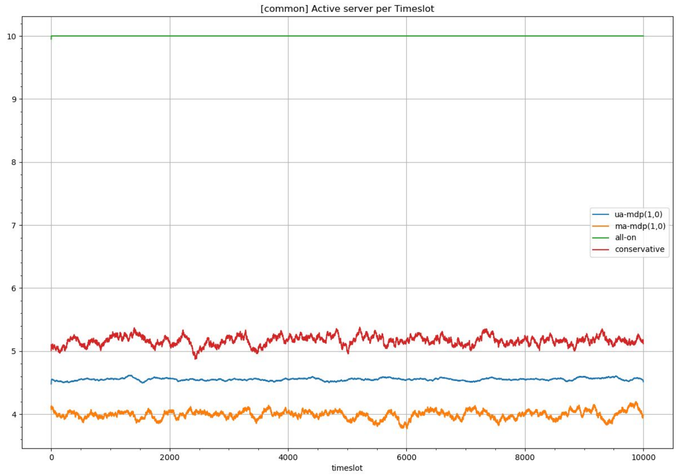

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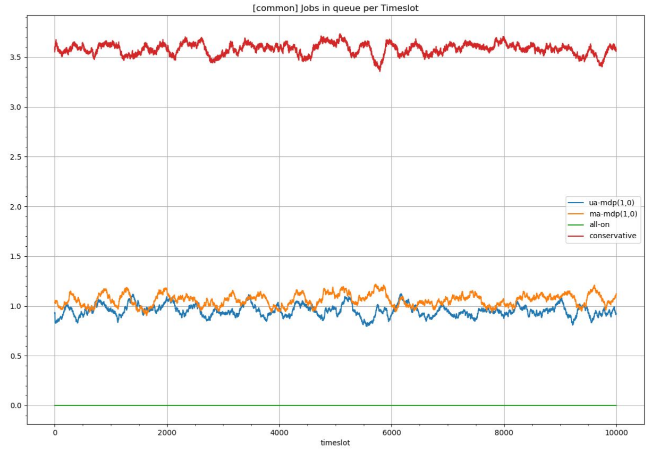
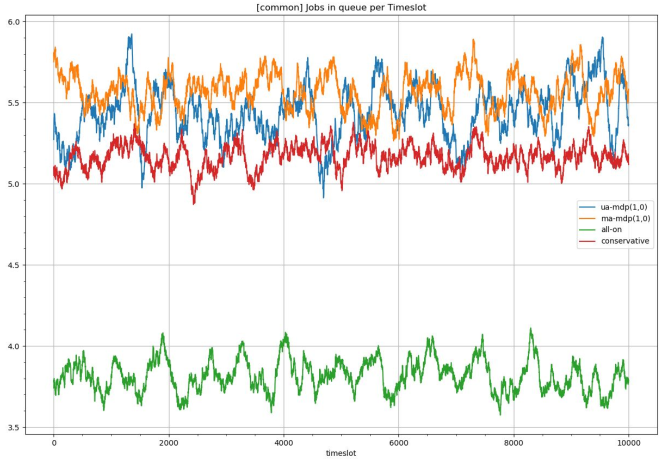
Scenario 1: Delayed Action + Default Assumptions VS Bayati's Assumptions

Default Assumptions



Bayati's Assumptions



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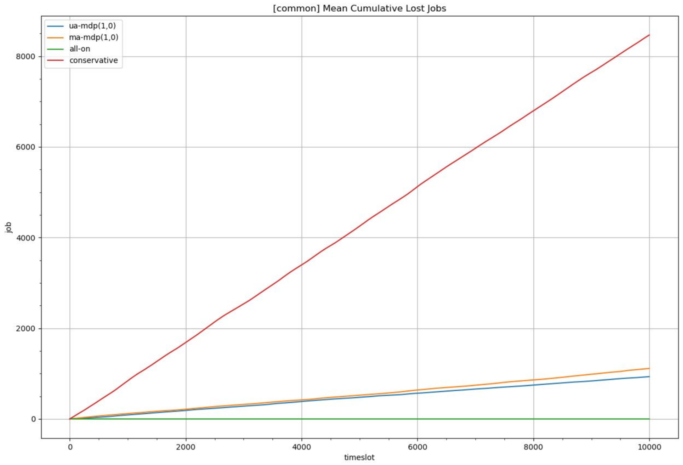
Scenario 1: Delayed Action + Default Assumptions VS Bayati's Assumptions

Default Assumptions



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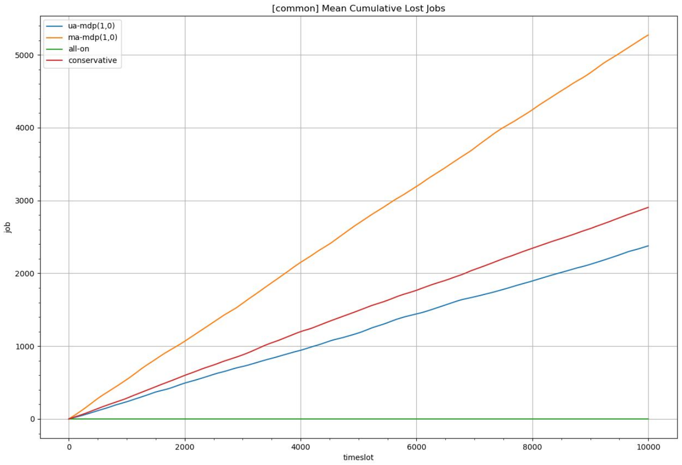

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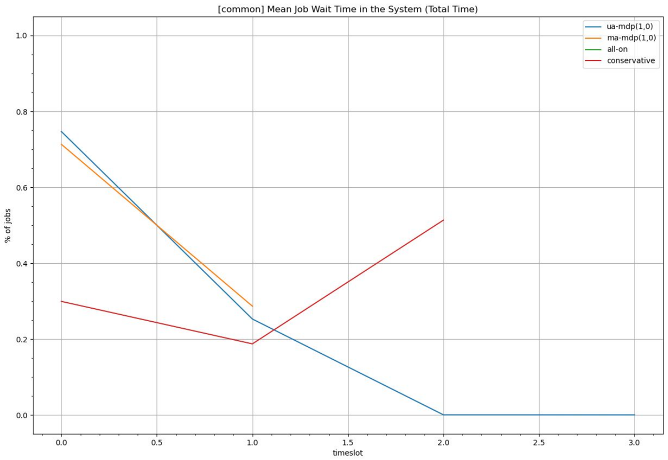

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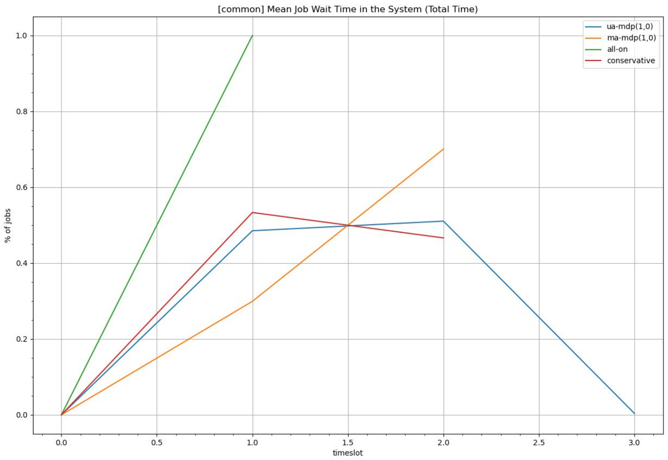

A slice simulator with MDP resolution

Scenario 1: Delayed Action + Default Assumptions VS Bayati’s Assumptions

Default Assumptions

ma-mdp(1,0) (ts 0)

	0 servers	1 servers	2 servers	3 servers	4 servers	5 servers	6 servers	7 servers	8 servers	9 servers	10 servers
0 jobs	8	8	7	6	6	5	5	5	5	5	5
1 jobs	9	8	8	7	6	6	5	5	5	5	5
2 jobs	10	9	8	8	7	6	6	5	5	5	5
3 jobs	10	10	9	8	8	7	6	6	5	5	5
4 jobs	10	10	10	9	8	8	7	6	6	5	5
5 jobs	10	10	10	10	9	8	7	6	6	5	5
6 jobs	10	10	10	10	9	8	7	7	6	5	5
7 jobs	10	10	10	10	10	9	8	7	6	5	5
8 jobs	10	10	10	10	10	9	8	7	6	5	5
9 jobs	10	10	10	10	10	9	9	8	7	6	5
10 jobs	10	10	10	10	10	10	9	8	7	6	5

A slice simulator with MDP resolution

Scenario 1: Delayed Action + Default Assumptions VS Bayati’s Assumptions

Bayati’s Assumptions

ma-mdp(1,0) (ts 0)

	0 servers	1 servers	2 servers	3 servers	4 servers	5 servers	6 servers	7 servers	8 servers	9 servers	10 servers
0 jobs	0	0	0	0	0	0	0	0	0	0	0
1 jobs	1	0	0	0	0	0	0	0	0	0	0
2 jobs	10	1	0	0	0	0	0	0	0	0	0
3 jobs	10	10	1	0	0	0	0	0	0	0	0
4 jobs	10	10	10	1	0	0	0	0	0	0	0
5 jobs	10	10	10	2	1	0	0	0	0	0	0
6 jobs	10	10	10	10	6	1	0	0	2	1	0
7 jobs	10	10	10	10	6	5	4	0	2	1	0
8 jobs	10	10	10	10	10	5	4	3	2	1	0
9 jobs	10	10	10	10	10	5	4	3	2	1	0
10 jobs	10	10	10	10	10	5	4	3	2	1	0

Scenario 2

Immediate Action :
Default Assumptions VS Bayati’s Assumptions

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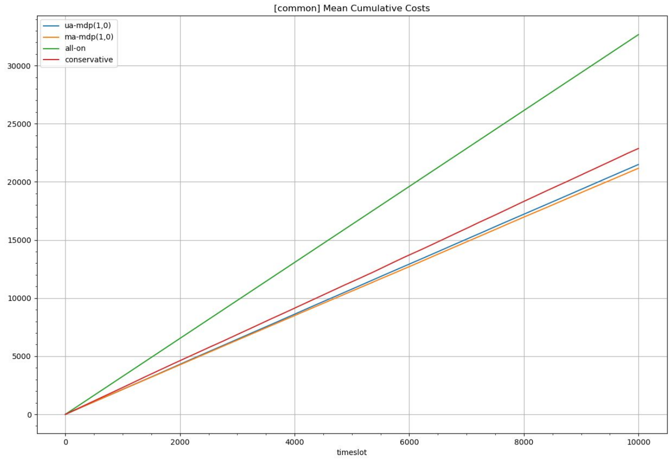
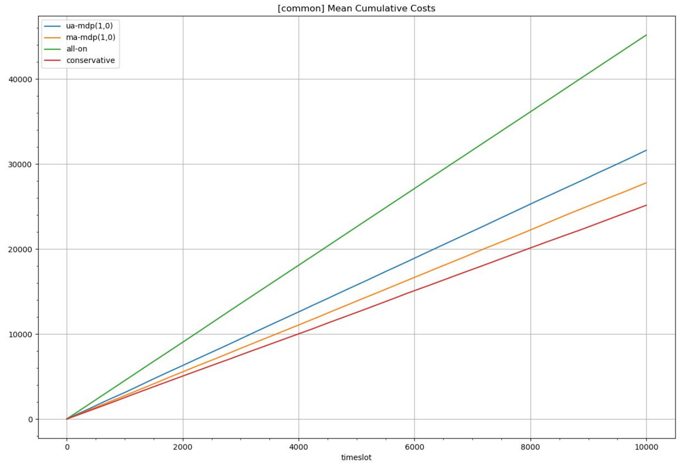
Scenario 2: Immediate Action + Default Assumptions VS Bayati's Assumptions

Default Assumptions



Bayati's Assumptions



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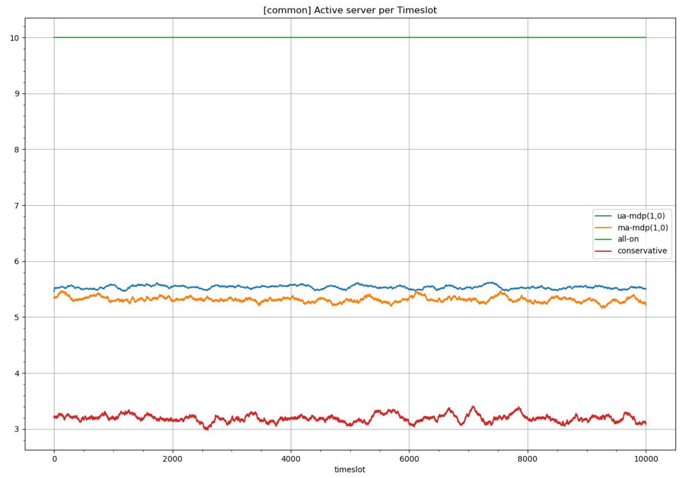
Scenario 2: Immediate Action + Default Assumptions VS Bayati's Assumptions

Default Assumptions



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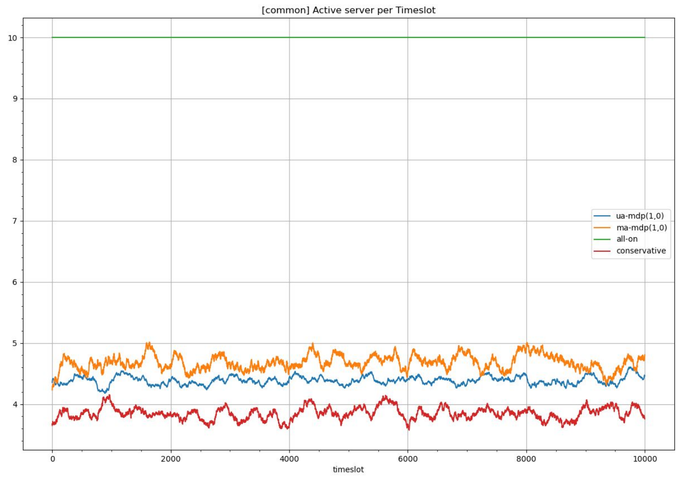

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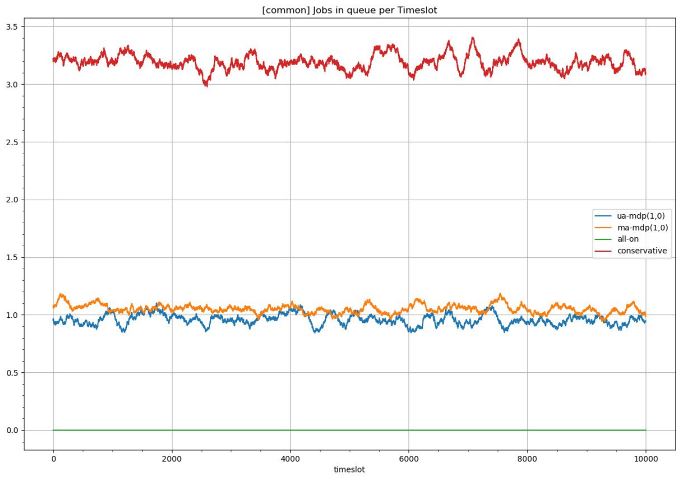
Scenario 2: Immediate Action + Default Assumptions VS Bayati's Assumptions

Default Assumptions



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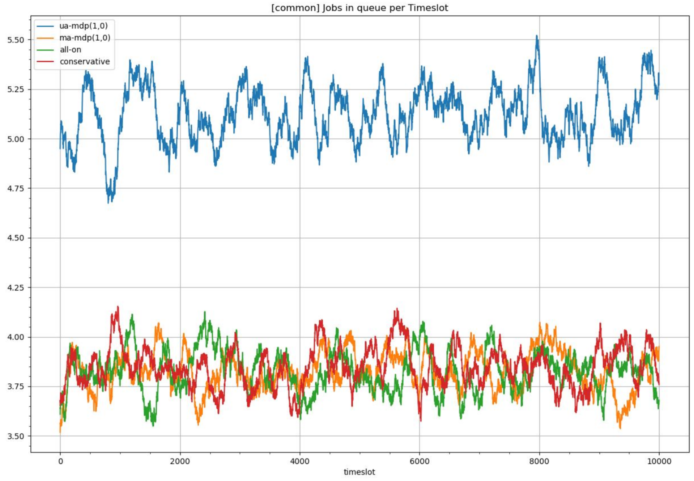

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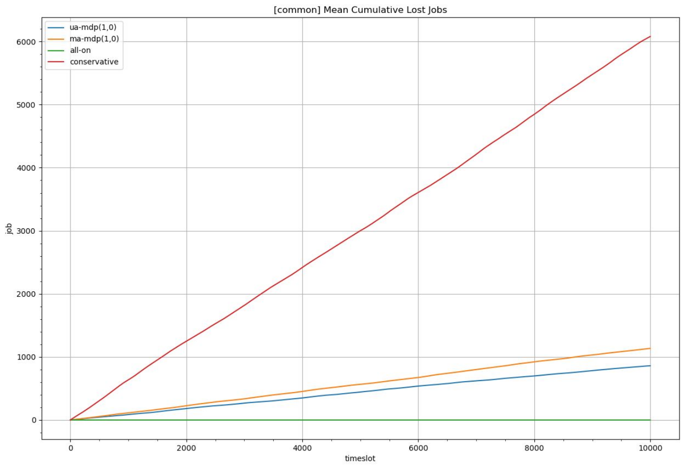
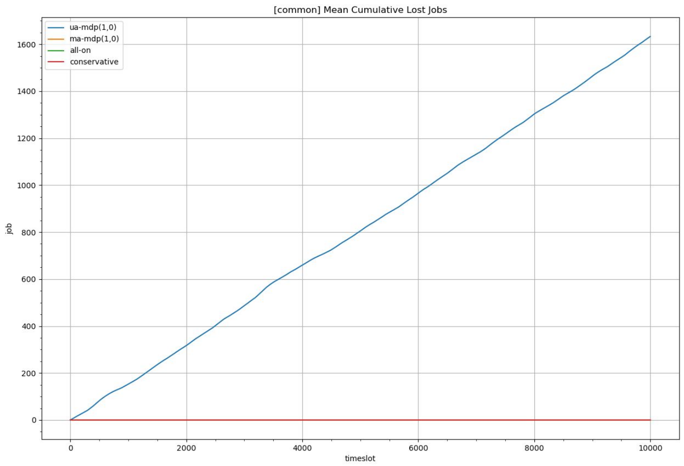
Scenario 2: Immediate Action + Default Assumptions VS Bayati's Assumptions

Default Assumptions



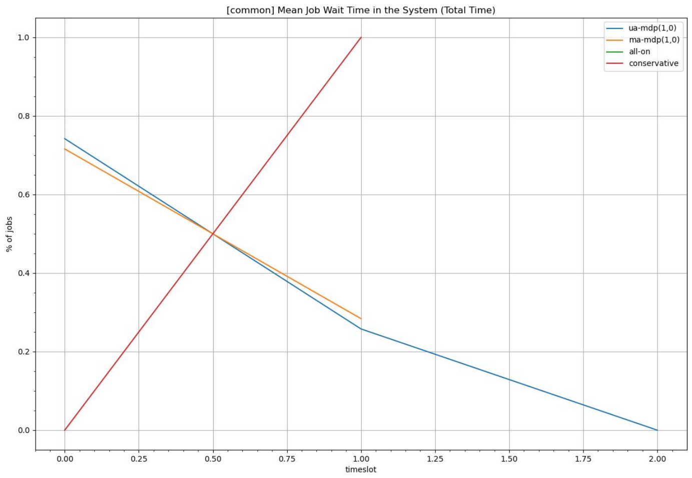
Bayati's Assumptions



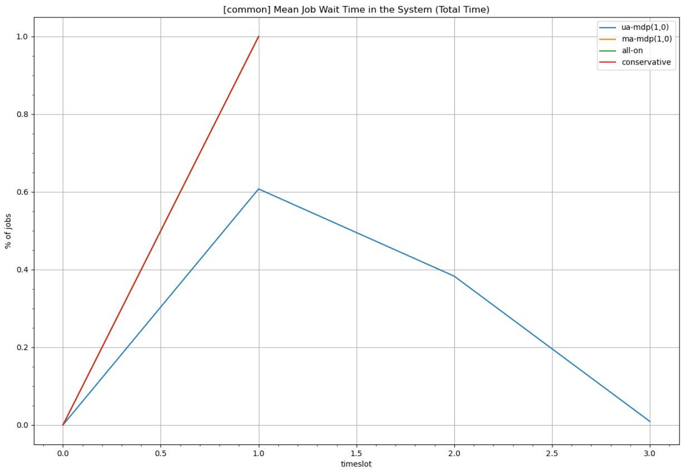
A slice simulator with MDP resolution

Scenario 2: Immediate Action + Default Assumptions VS Bayati's Assumptions

Default Assumptions



Bayati's Assumptions



A slice simulator with MDP resolution

Scenario 2: Immediate Action + Default Assumptions VS Bayati's Assumptions

Default Assumptions

ma-mdp(1,0) (ts 0)

	0 servers	1 servers	2 servers	3 servers	4 servers	5 servers	6 servers	7 servers	8 servers	9 servers	10 servers
0 jobs	4	4	4	4	4	4	4	4	4	4	4
1 jobs	5	5	5	5	5	5	5	5	5	5	5
2 jobs	7	7	7	7	7	7	7	7	7	7	7
3 jobs	8	8	8	8	8	8	8	8	8	8	8
4 jobs	9	9	9	9	9	9	9	9	9	9	9
5 jobs	10	10	10	10	10	10	10	10	10	10	10
6 jobs	10	10	10	10	10	10	10	10	10	10	10
7 jobs	10	10	10	10	10	10	10	10	10	10	10
8 jobs	10	10	10	10	10	10	10	10	10	10	10
9 jobs	10	10	10	10	10	10	10	10	10	10	10
10 jobs	10	10	10	10	10	10	10	10	10	10	10

A slice simulator with MDP resolution

Scenario 2: Immediate Action + Default Assumptions VS Bayati's Assumptions

Bayati's Assumptions

ma-mdp(1,0) (ts 0)

	0 servers	1 servers	2 servers	3 servers	4 servers	5 servers	6 servers	7 servers	8 servers	9 servers	10 servers
0 jobs	0	0	0	0	0	0	0	0	0	0	0
1 jobs	1	1	1	1	1	1	1	1	1	1	1
2 jobs	2	2	2	2	2	2	2	2	2	2	2
3 jobs	3	3	3	3	3	3	3	3	3	3	3
4 jobs	4	4	4	4	4	4	4	4	4	4	4
5 jobs	5	5	5	5	5	5	5	5	5	5	5
6 jobs	10	10	10	10	10	10	10	10	10	10	10
7 jobs	10	10	10	10	10	10	10	10	10	10	10
8 jobs	10	10	10	10	10	10	10	10	10	10	10
9 jobs	10	10	10	10	10	10	10	10	10	10	10
10 jobs	10	10	10	10	10	10	10	10	10	10	10

Backup

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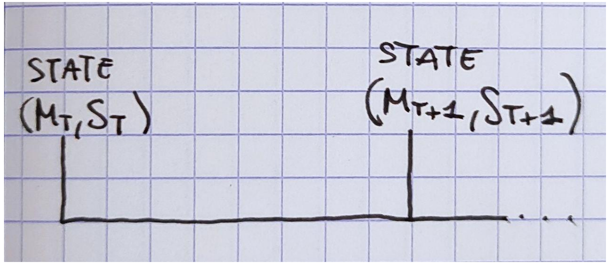
Formulation - Assumption

Delayed Action (timeslot view):

1. State
2. Action chosen according to the state
3. Arrival phase (losses)
4. Processing phase
5. Execution of the action chosen in (2)



Immediate Action (timeslot view):

1. State
2. Action chosen according to the state
3. Execution of the action chosen in (2)
4. Arrival phase (losses)
5. Processing phase

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Formulation - Assumptions of L. M. Bayati's Thesis

"We begin by serving the waiting jobs of the buffer, next we fill the free operational servers by the new jobs, then we fill the buffer." [1.3.1]

"At the beginning of each slot, and based on the current state of the system, an action $\alpha_j \in A$ will be made to determine how many servers will be operational during the current slot." [4.1.2.1]

Immediate Action + phases exchange (timeslot view):

1. State
2. Action chosen according to the state
3. Execution of the action chosen in (2)
4. Processing phase
5. Arrival phase (losses)