Hasso Plattner Institut
Digital Engineering · Universität Potsdam

“Hey, I need something to do!”
Machine Learning in Human Resource Allocation

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All icons from https://thenounproject.com/

Project Management Triangle

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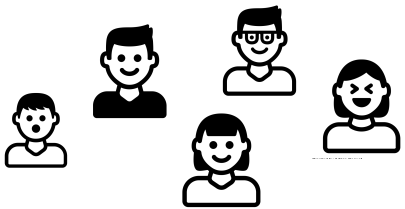
What is Resource Allocation?



Resource

+

different tasks

=

Allocation

Task *XY* will be executed by *employee 1*.

The Challenge

Log Data with assignments

Learning of
What task
by who and
with which duration.

On run time allocation

TRAINING

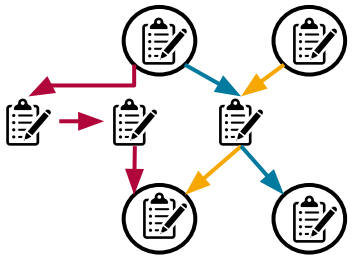
PREDICTION

Machine Learning Algorithm

Log Data

Using the log data from the **Fifth International Business Process Intelligence Challenge (BPIC'15):**

- Background information:
  - front desk computer systems of the five municipalities
  - recorded activities having an impact on the environment
- several valid start and endpoints



Exemplary data
`BPIC15_1.xes`

52,217 Events

1,199 Cases

398 Activities

23 Resources

Log Data: Event

```
<event>
       <string key="monitoringResource" value="560519"/>
       <string key="org:resource" value="560532"/>
       <string key="activityNameNL" value="registratie datum binnenkomst aanvraag"/>
       <string key="concept:name" value="01_HOOFD_010"/>
       <string key="question" value="EMPTY"/>
       <string key="dateFinished" value="2013-03-26 15:15:32"/>
       <string key="action_code" value="01_HOOFD_010"/>
       <string key="activityNameEN" value="register submission date request"/>
       <date key="planned" value="2012-08-09T09:34:11+02:00"/>
       <string key="lifecycle:transition" value="complete"/>
       <date key="time:timestamp" value="2012-08-07T00:00:00+02:00"/>
 </event>
```

employee-id

actual end time

activity

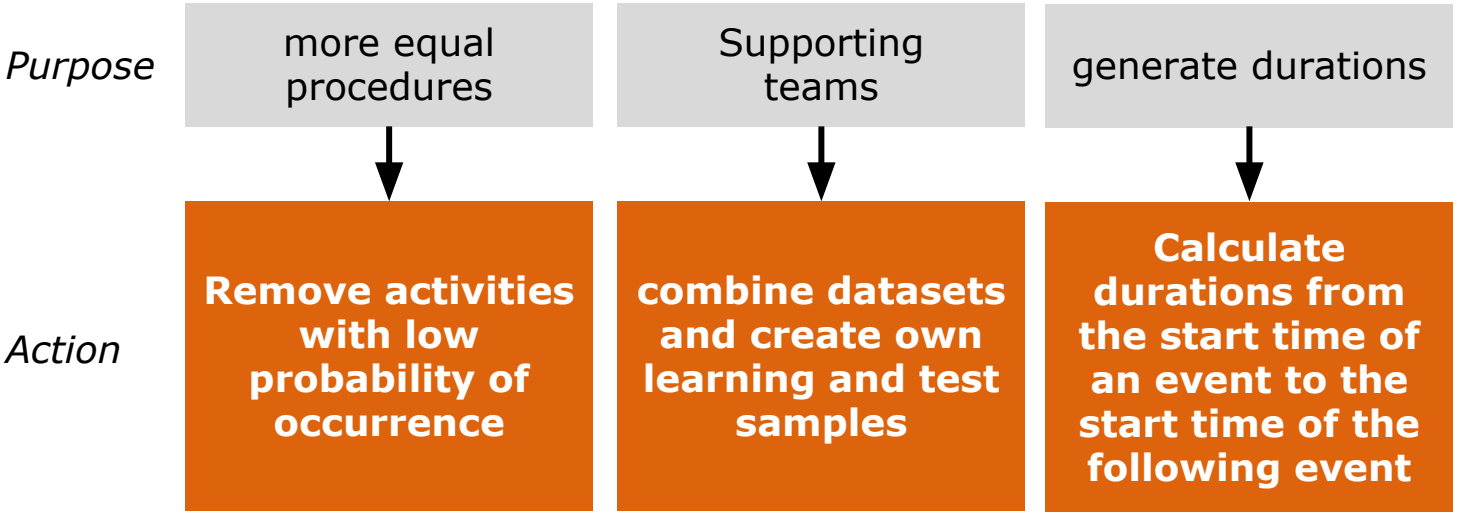
planned end time

start time

Log Data: Insights and Limitations

Organizational structure	Process Flow
most activities were performed by the same 2-3 resources [11]	mostly each case is an unique variant [12]
rarely high frequencies for a resource to perform a given phase [10]	the main process flow is mainly identical [12]
existens of cross-municipal-resources [10]	some events of the same trace have the same timestamp [10]
there are existing kind of certain roles [10][12]	

Prepare Dataset



Input for our Machine Learning Algorithm: Traces

Related Work

MODEL
Fuzzy Logic Strategy

ALLOCATION
Hungarian Method
[1]

Machine Learning Algorithm

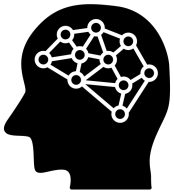
Classification

Naïve Bayes
[2] [3]

Decision Tree Learning
[8]

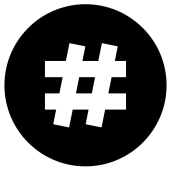
Reinforcement Learning
[4] [5] [6] [7]

Related Work: Reinforcement Learning approaches



Deep Reinforcement Learning [6]

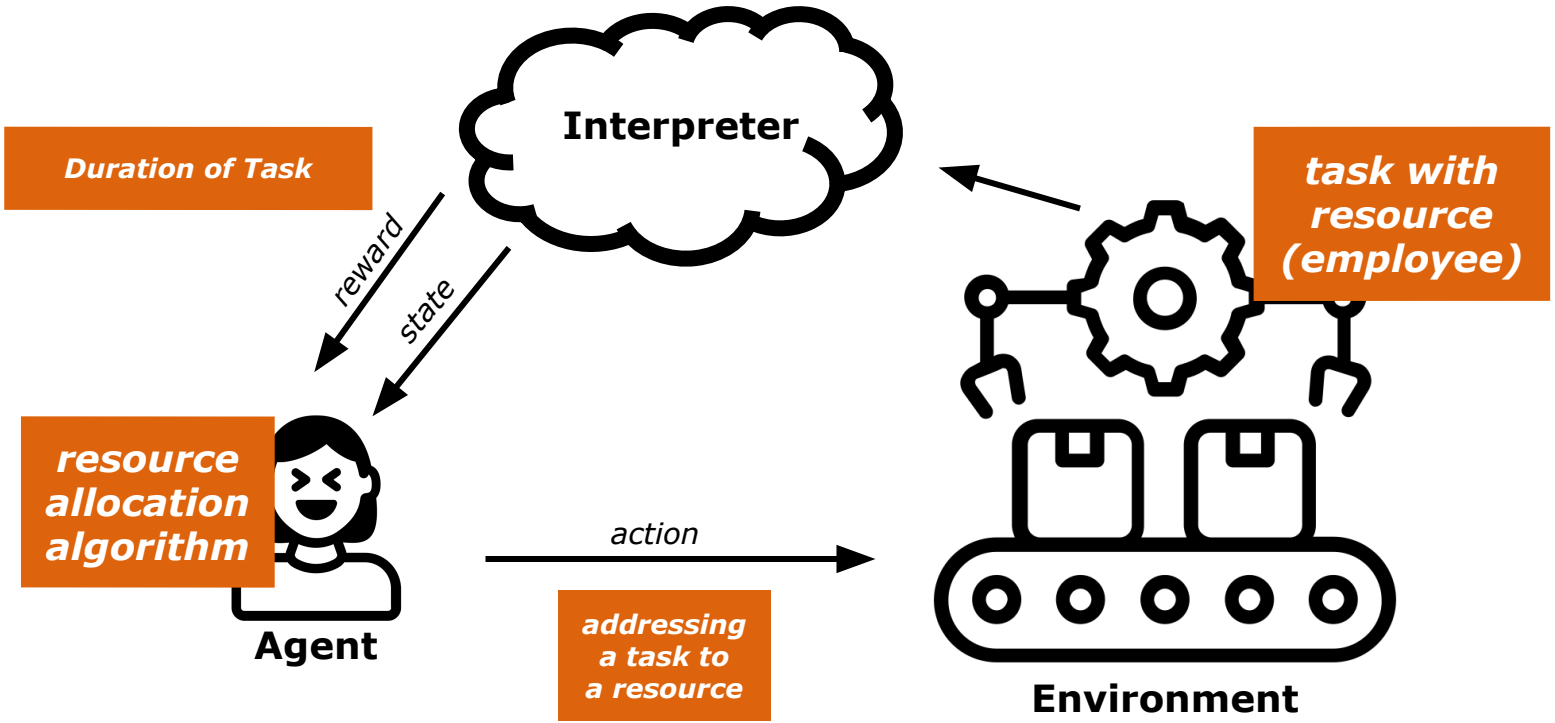
- Objective: **minimize the average job slowdown**
- Reward function: based on **the reciprocal duration** of the job



Extending **Q-learning** algorithm for:

- scheduling tasks based on **priority rules** [4]
- taking **previous ressources** into consideration [5]
- allocating **similar jobs in frequent intervals** to a resource [7]

Reinforcement Learning



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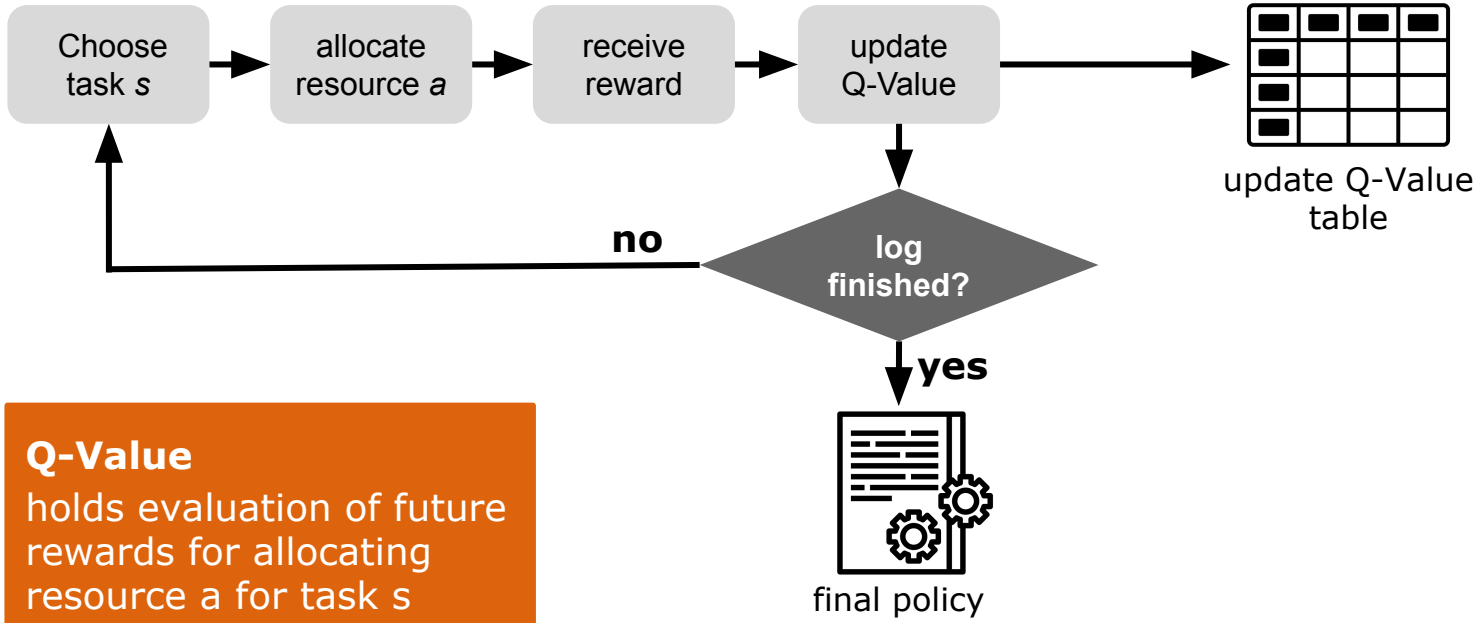
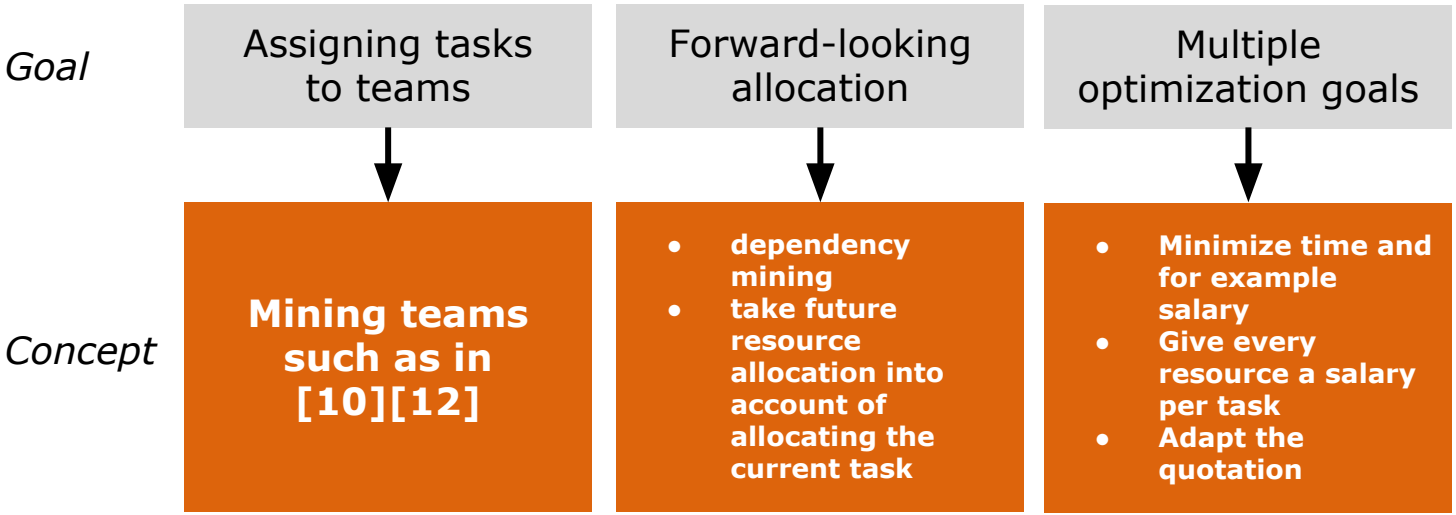
Q-Learning Algorithm



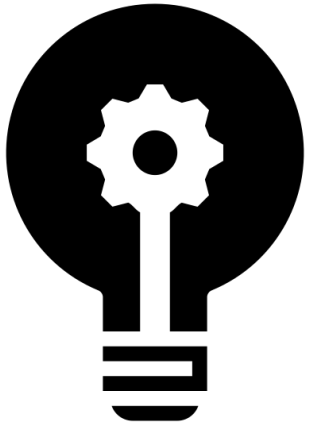
Q-Value
holds evaluation of future rewards for allocating resource a for task s

Future Improvements



Take away

- **Human Resource Allocation Problem**
- **Reinforcement Learning** is a popular and powerful method for allocation on time jobs
- our **attempt/concept**
  - Q-Learning
  - extending for
    - Team assignments
    - Forward-looking allocation
    - Multiple optimization goals



Literature

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[10] Irene Teinemaa, Anna Leontjeva and Karl-Oskar Masing (2015). BPIC 2015: Diagnostics of Building Permit Application Process in Dutch Municipalities. 11th International Workshop on Business Process Intelligence 2015.

[11] Ube van der Ham (2015). Benchmarking of Five Dutch Municipalities with Process Mining Techniques Reveals Opportunities for Improvement. 11th International Workshop on Business Process Intelligence 2015.

[12] Liese Blevi and Peter Van den Spiegel (2015). Discovery and analysis of the Dutch permitting process. 11th International Workshop on Business Process Intelligence 2015.

[13] Scott Buffett and Bruno Emond (2015). Using Sequential Pattern Mining and Social Network Analysis to Identify Similarities, Differences and Evolving Behaviour in Event Logs

Q-Learning reinforcement learning algorithm

$$Q'(s,a) = (1-\alpha) * Q(s,a) + \alpha * (r(a) + \gamma \min(Q(s',a')))$$

new Q-Value | **current Q-Value** | **Reward** | **Q-Value of next state**

Q-Learning reinforcement learning algorithm

Q(s,a)	Q-Value for state s if you take action a
Q’(s,a)	new Q-Value for state s if you take action a
α	Adjust the importance of the old Q-Value in calculation of the new one
r(a)	Reward the agent gets for executing action a
argmin(Q(s’,a’))	Smallest Q-Value of next state s’