Information Society Technologies

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A framework for developmental learning of Affordances

MACS 3rd Review

Sankt Augustin, 15th Feb 2008

Florian Kintzler, Jörg Irran, Georg Dorffner

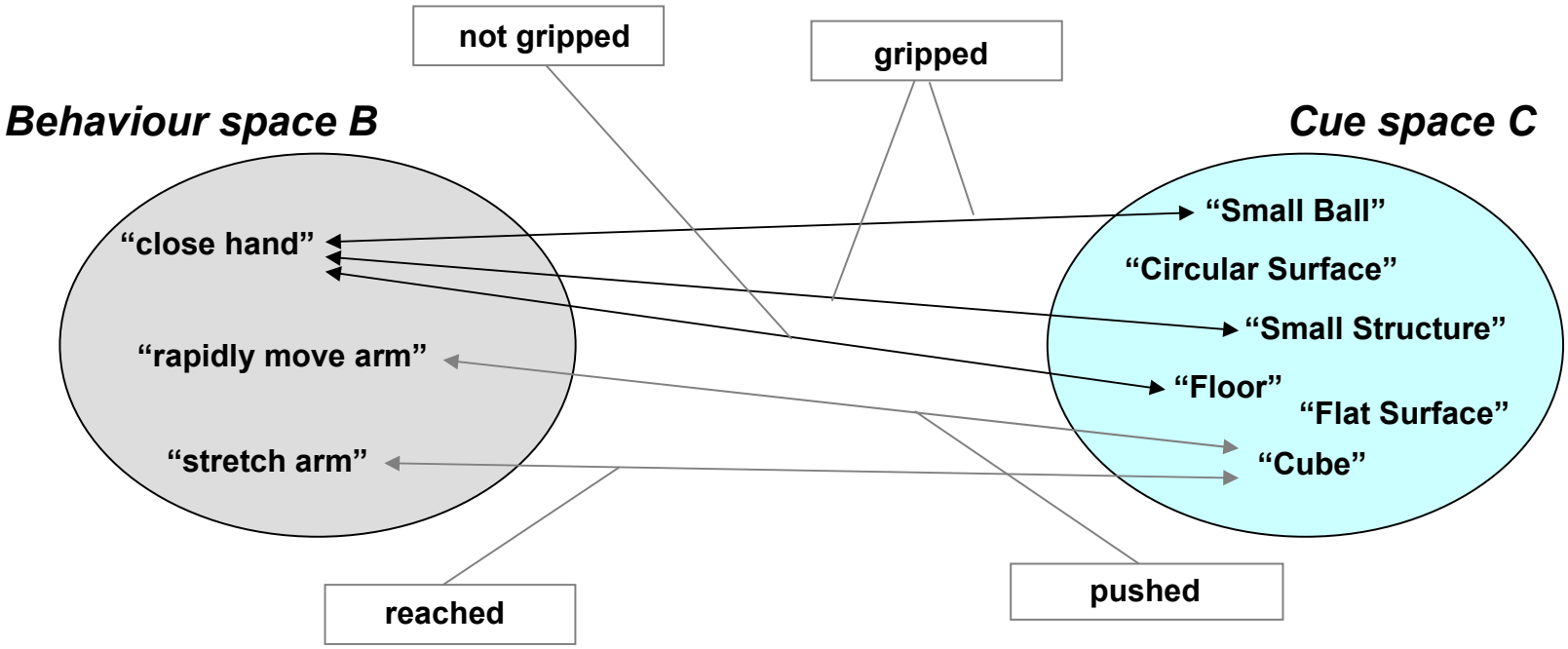
(OFAI)

Outline

- Learning of Affordances – Concept
- Behaviour-Monitoring/Self Observation (LM, ESGM and PM)
- Learning-Algorithm (LM)
  - Clustering of data from one channel
  - Finding correlating channels
  - Re-Learning
- Using the derived knowledge:
  - Generating Filters – (ESGM and ARR)
  - Using the generated filters (ESGM, ARR, DM and BM)
- Connection to Cue-Learning by JR_DIB (LM, PM)
- Outlook

Affordance

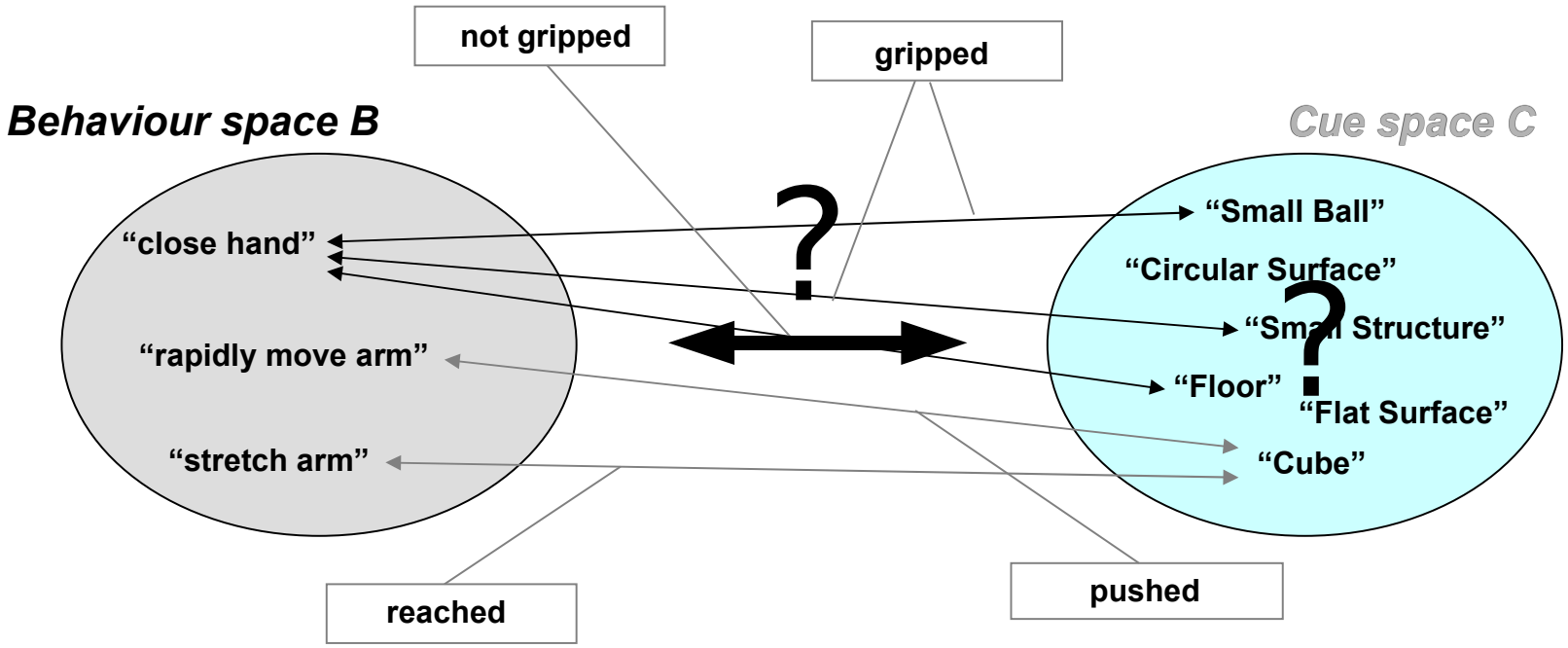
Initial Idea – Learning Perspective



"The *affordances* of the environment are what it *offers* the animal, what it *provides* or *furnishes*, either for good or ill. […]

I mean by it [affordances] something that **refers to both** the environment and the animal." (Gibson, 1986)

Affordance
Agents View

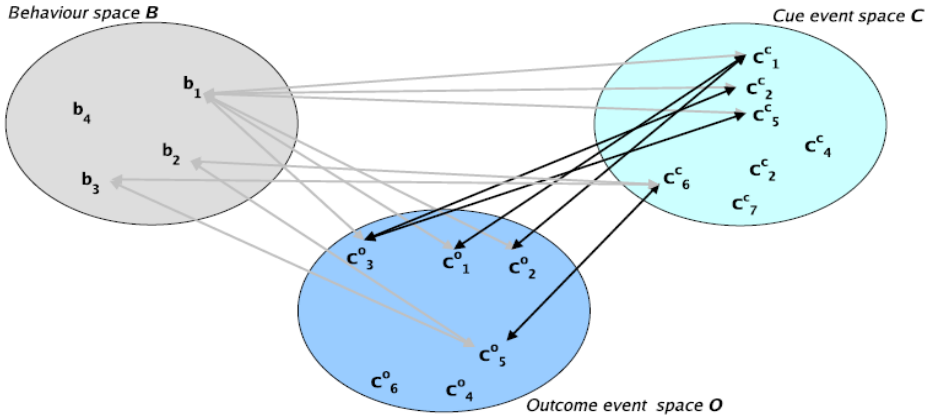


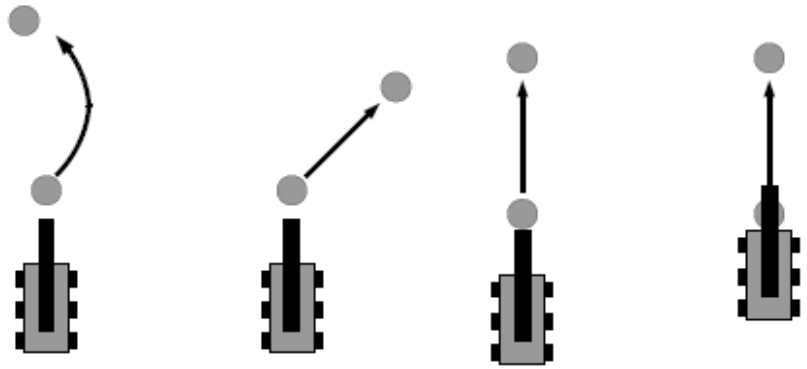
- Behaviours, Outcomes, Cues
- There is no meaning of one without the other

Learning of Affordances

Concept -Observing Own Behaviour

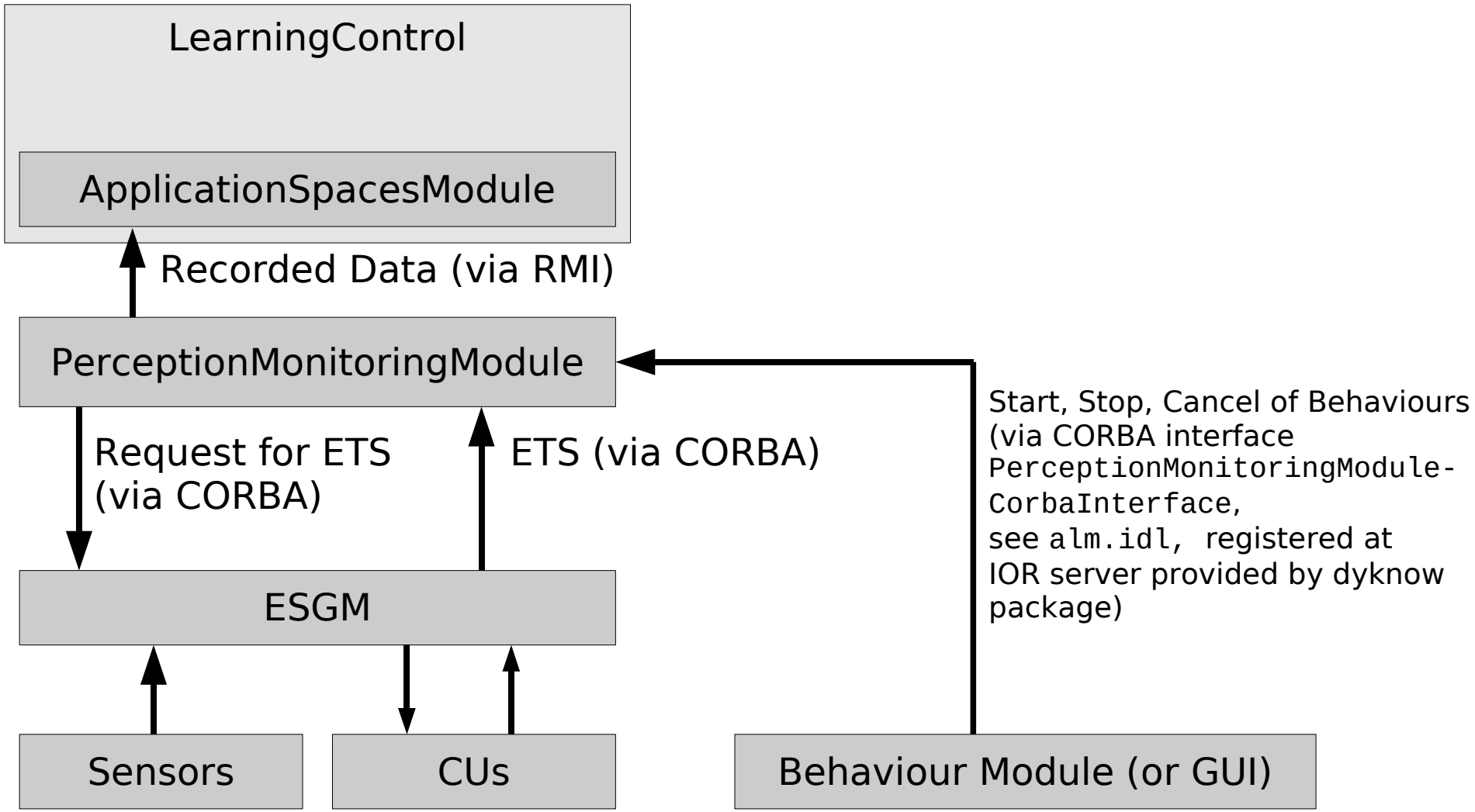
- One behaviour can cause multiple outcome events
- Multiple behaviours can cause similar outcome events
- One cue can indicate the possibility to apply multiple behaviours
- Multiple cues can indicate the possibility to apply one behaviour





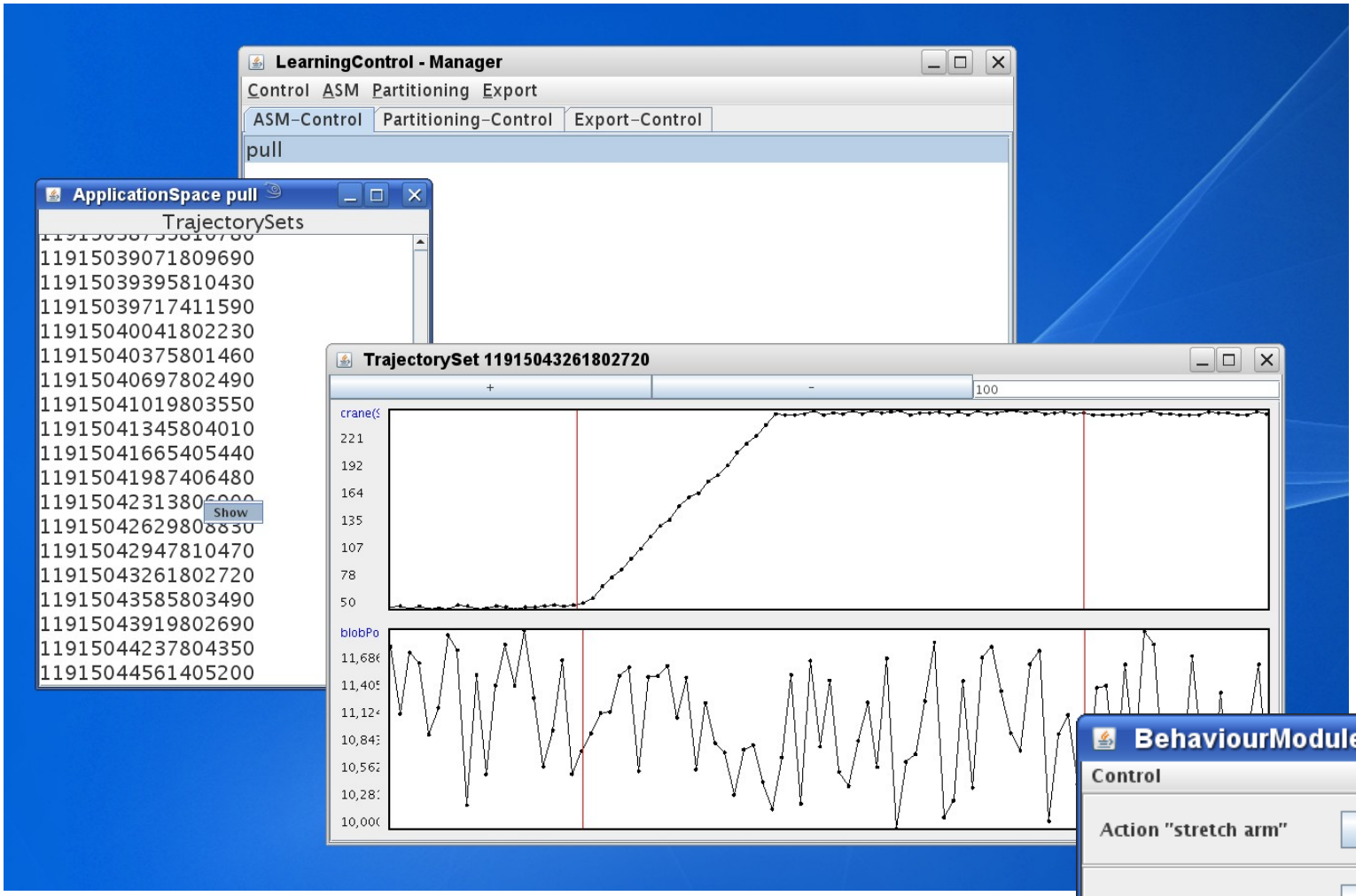
Monitoring of Perception and Behaviour

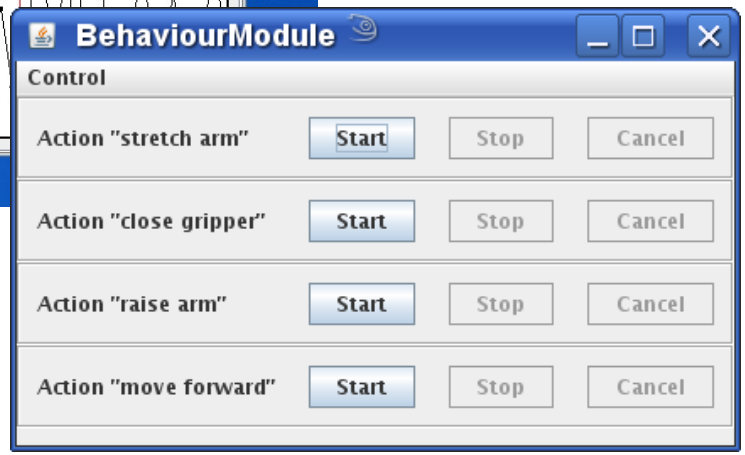
Application Flow



Monitoring of Perception and Behaviour

GUI





Monitoring of Perception and Behaviour

Implementation – Problems and Solution

- Sun JDK-ORB, IBM JDK-ORB, OpenORB are not compatible with ESGM
- JacORB compiles the idl files, but the class *AttributeValuePair* is empty.
- Added the following lines to class *AttributeValuePair*:

```
public String name;
public Value val;
```

- Added the following lines to method `read(...)` in class *AttributeValuePairHelper* (method write analogue):

```
result.name=in.read_string();
result.val=ValueHelper.read(in);
```

- Helper classes (like `SubscriptionProxy`) that are provided in native C/C++ were re-implemented

Partition an Application-Space

Clustering of Data from One Sensor Channel

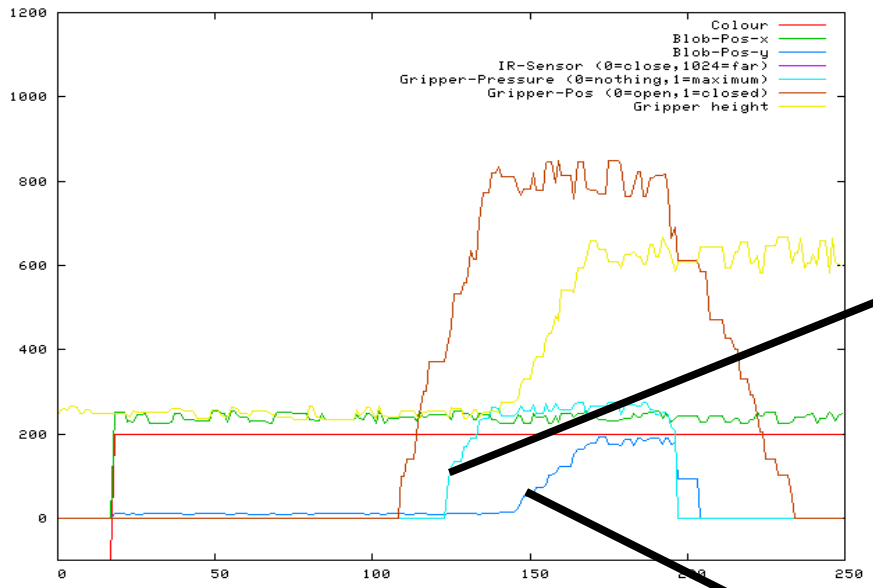
- Learning Approach described in D5.3.1

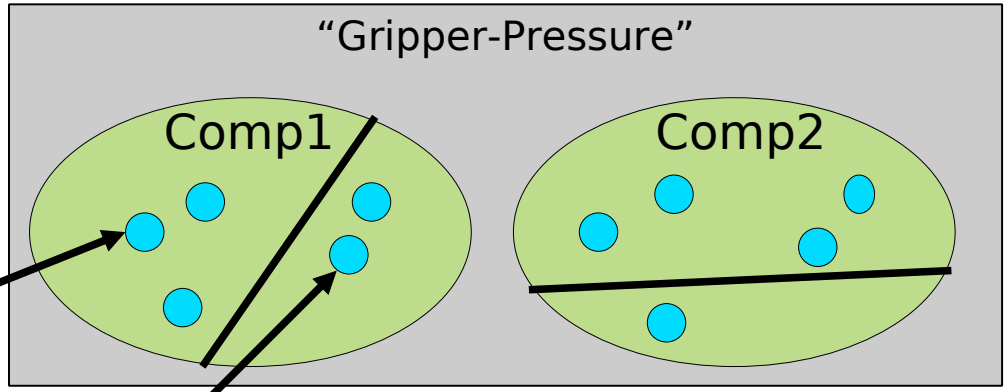
$$
\begin{aligned}
S_j^o(a_i) &= S\left(\{t[o](a_i)\,|t(a_i) \in P_j(a_i)\,\}\right) \\
&= S\left(\{t[State_{t1}, State_{t2} + \delta_{t2}](a_i) \mid t(a_i) \in P_j(a_i)\}\right) \\
&= \{s_1^o[P_j(a_i)], s_2^o[P_j(a_i)] \ldots\}\,, \\
&\quad \text{for each partition } j, 0 \leq i < N
\end{aligned}
$$

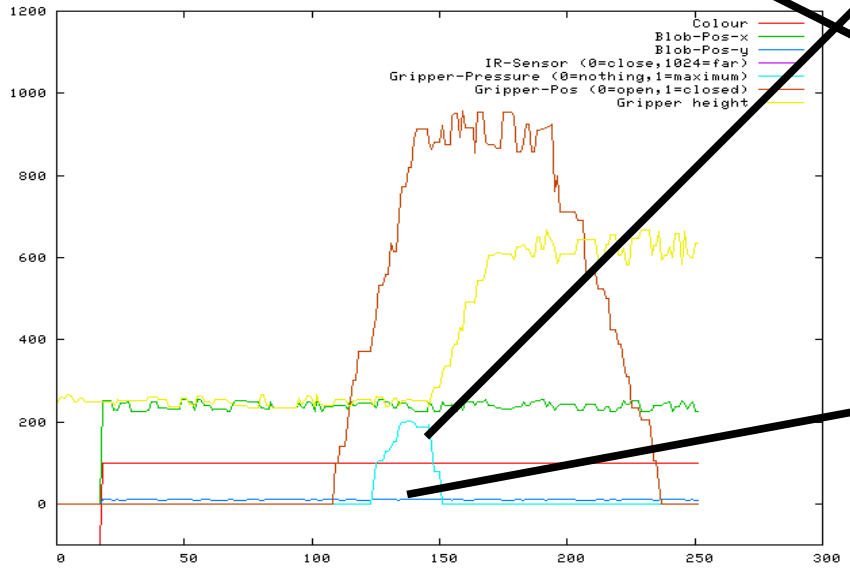
- Procedure is implemented data type independent
- New types of data can be handled by providing
  - the data type *T*
  - Comparator(s!) to compare time series consisting of data of data type *T*
  - GUI components for displaying (optional)

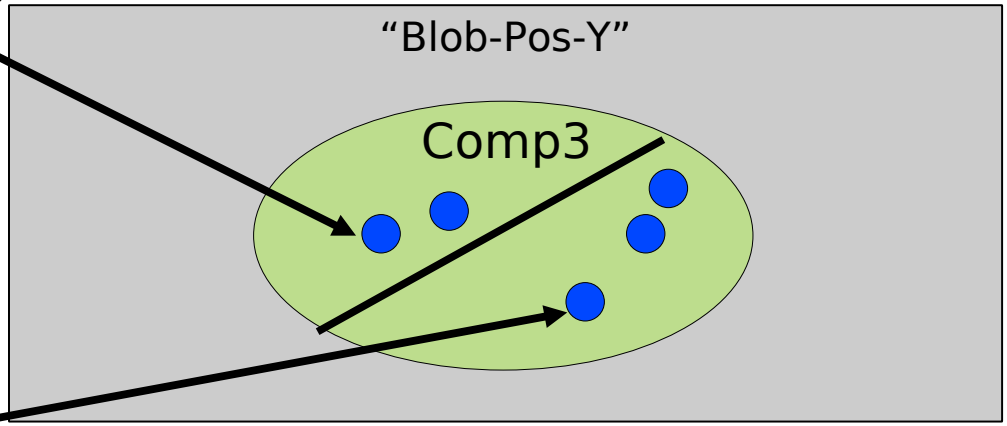
Partition an Application-Space

Clustering of Data from One Sensor Channel



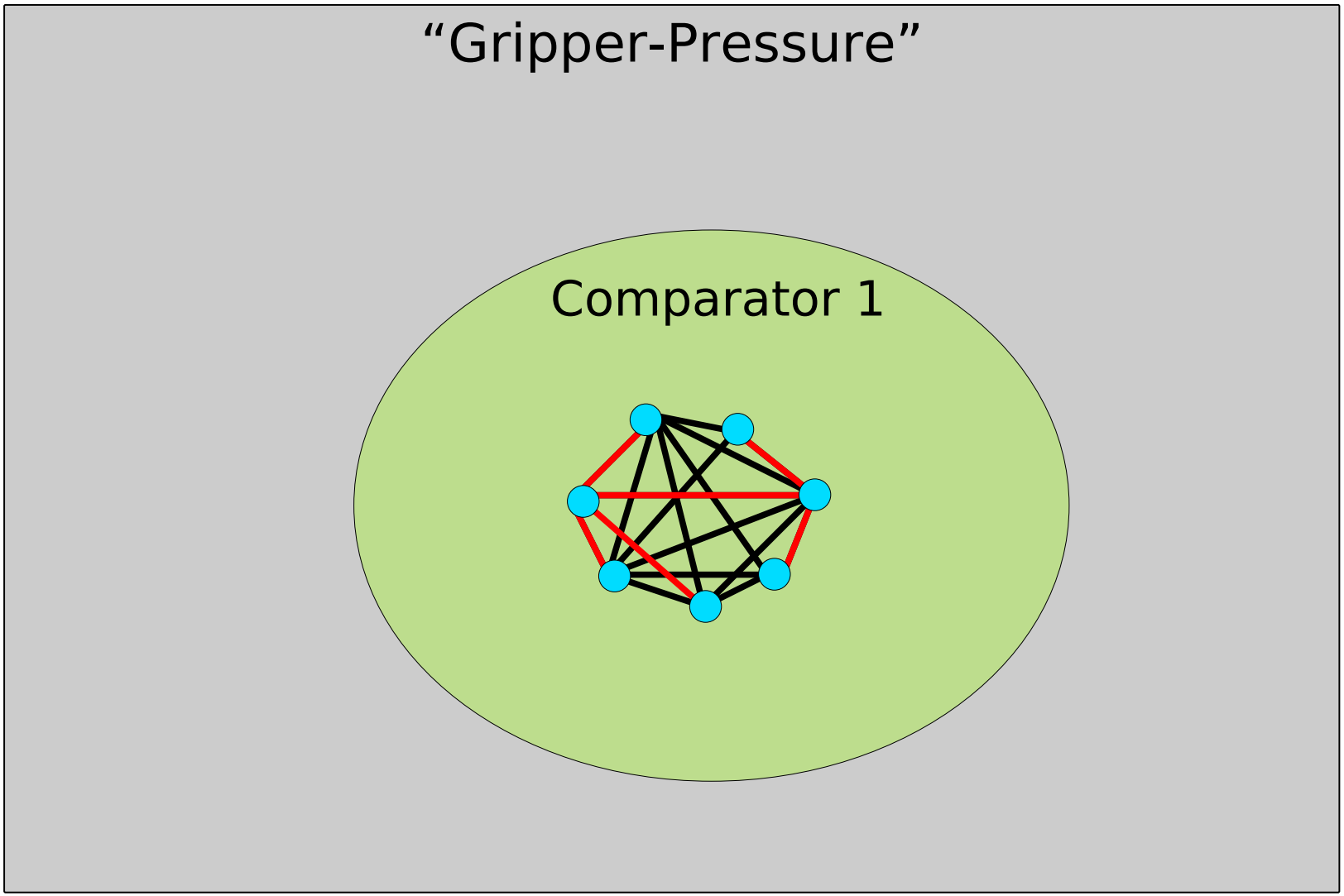






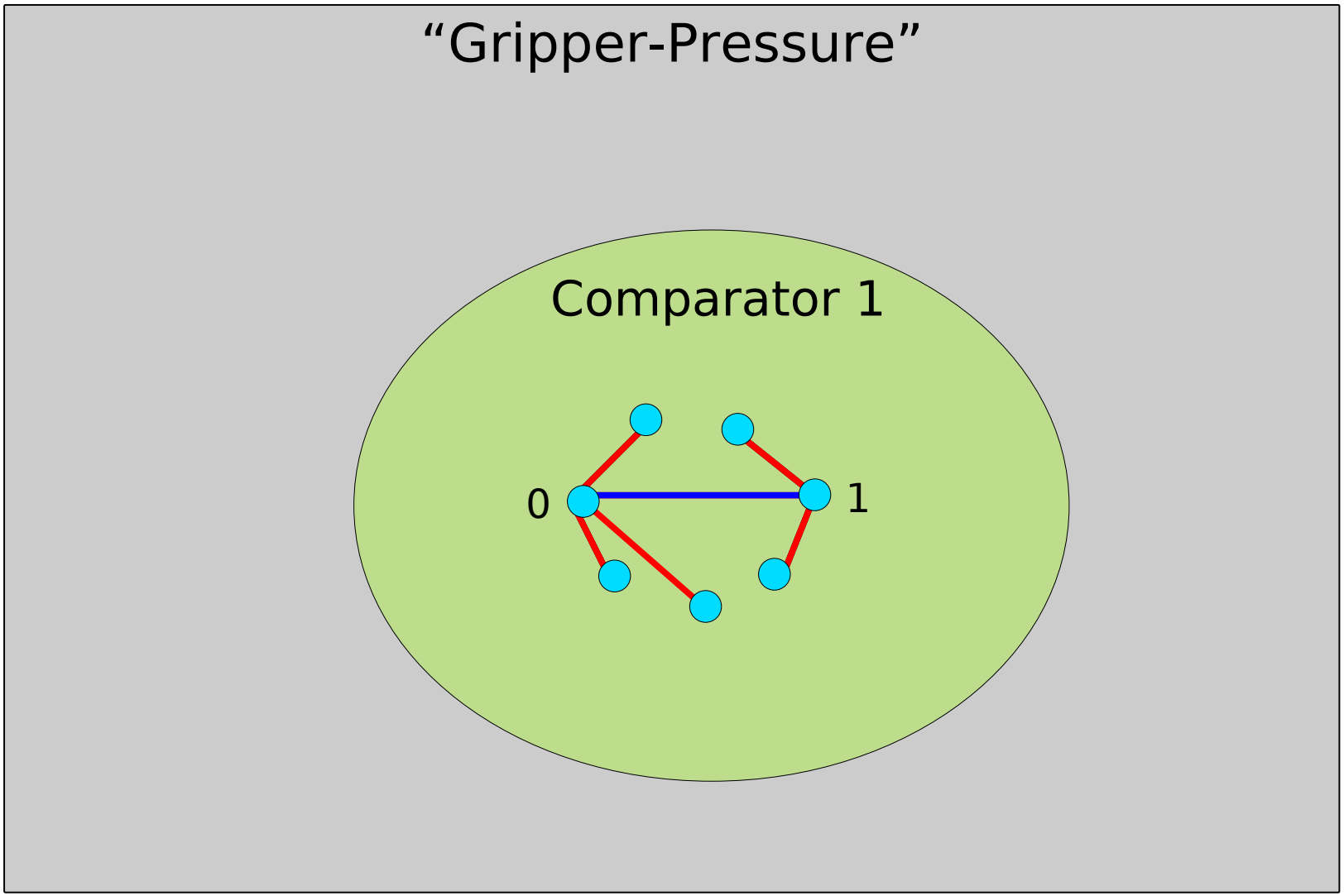
Partition an Application-Space

Clustering of Data from One Sensor Channel



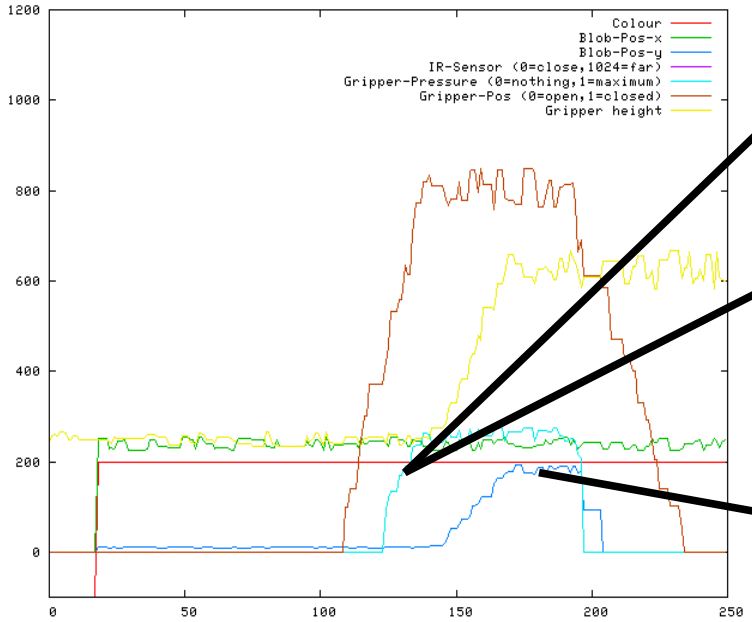
Partition an Application-Space

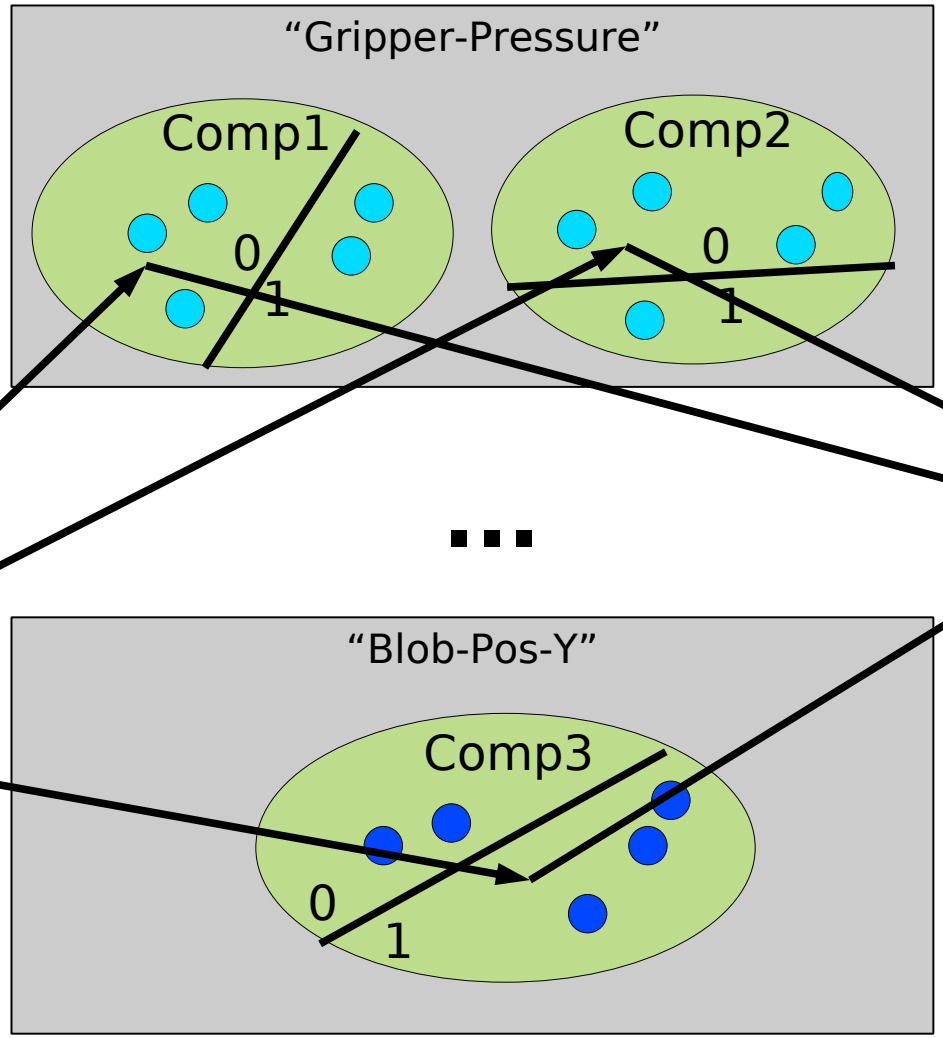
Clustering of Data from One Sensor Channel



Partition an Application-Space

Clustering of Data from One Sensor Channel





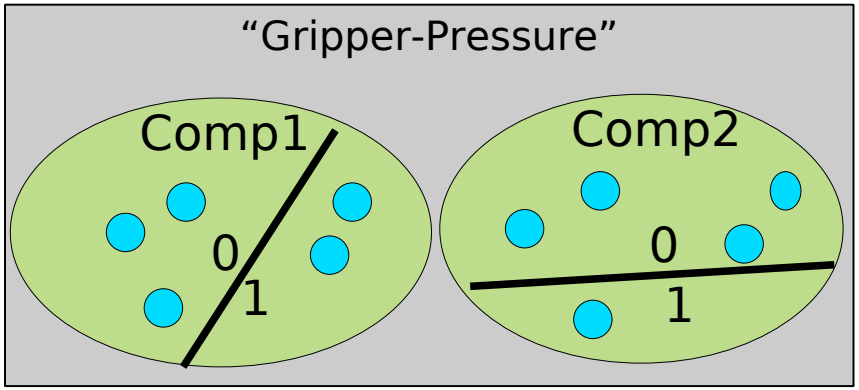
Partition an Application-Space

Finding Correlating Channel-Clusters

- Transfers all available time series sets into cluster-vectors
- Tries to find correlations between the clusters, i.e. matches like “whenever the data of channel A belongs to cluster Cx,y the the data of channel B belongs to cluster Cz,r” (can also include or-relations)
- Implementation is thus data type independent
- Can be used independent of the concrete implementation of the clustering of data channel specific data

Partition an Application-Space

Finding Correlating Channel-Clusters



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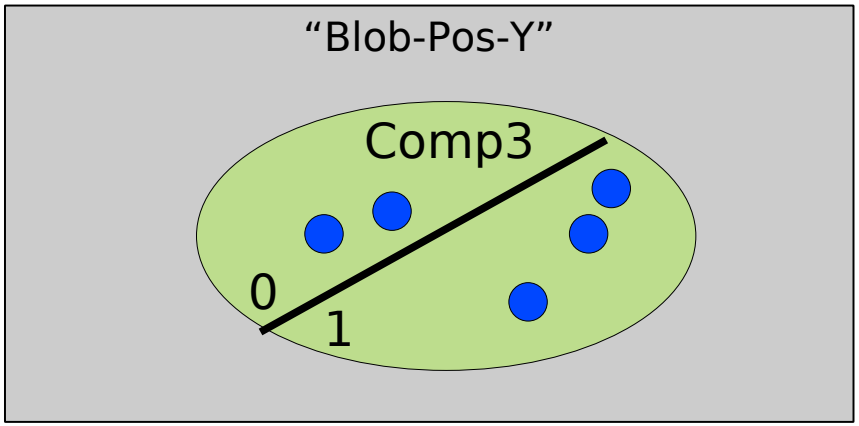
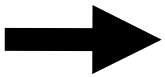




Gripper-Pressure, Cluster C1,0

Gripper-Pressure, Cluster C1,1

Gripper-Pressure, Cluster C2,0

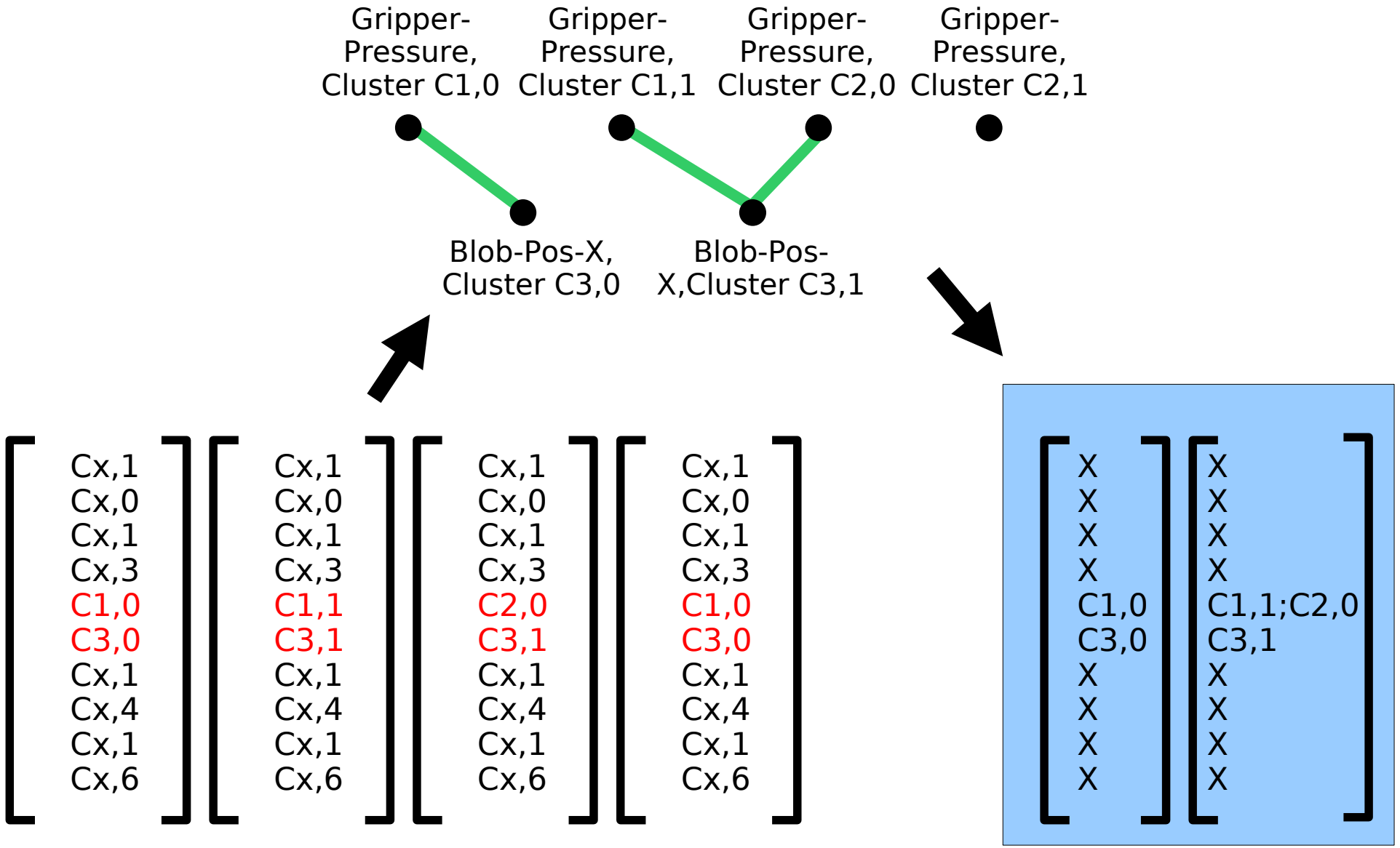
Gripper-Pressure, Cluster C2,1

Blob-Pos-X, Cluster C3,0

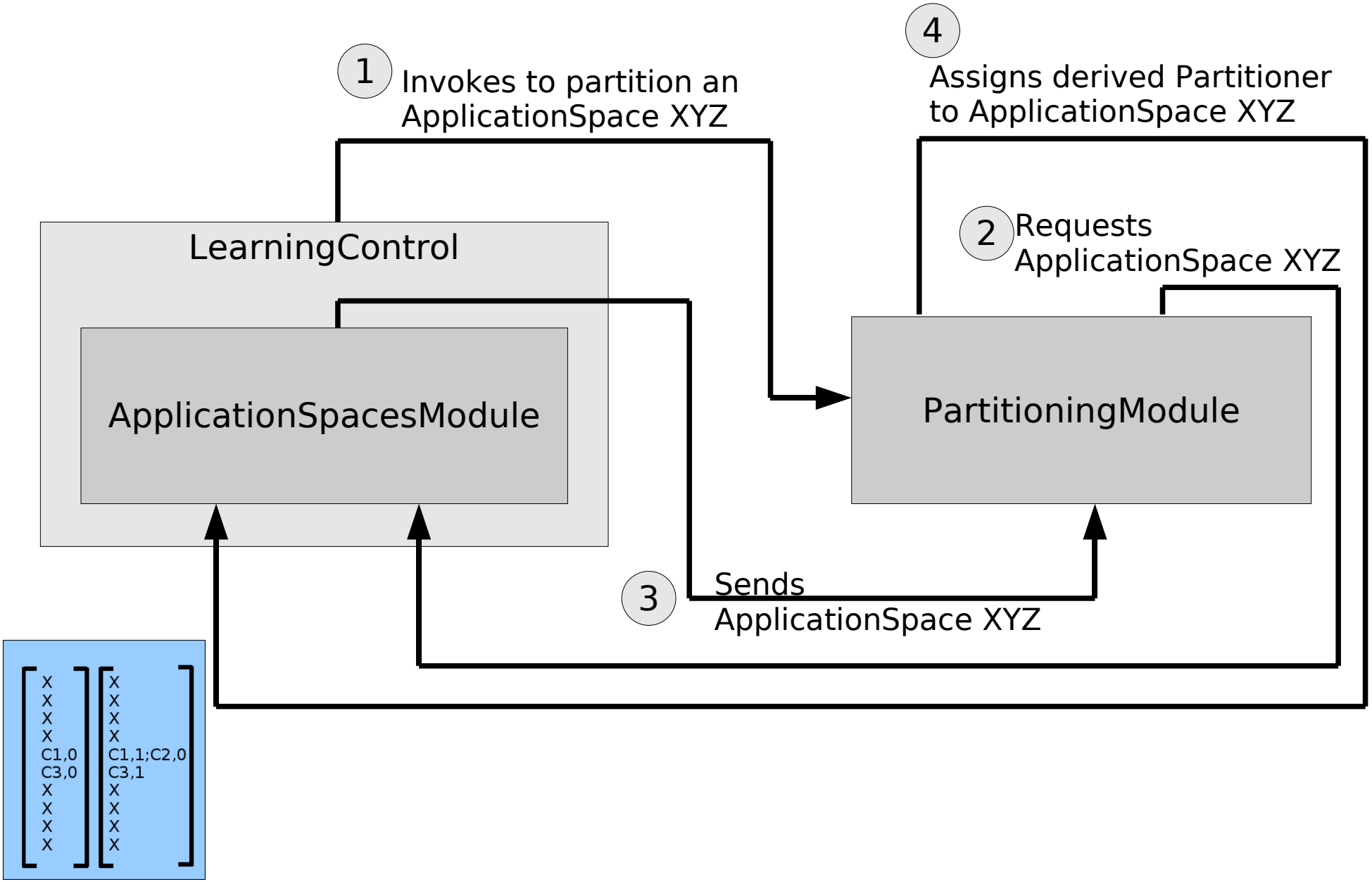
Blob-Pos-X,Cluster C3,1

Partition an Application-Space

Finding Correlating Channel-Clusters

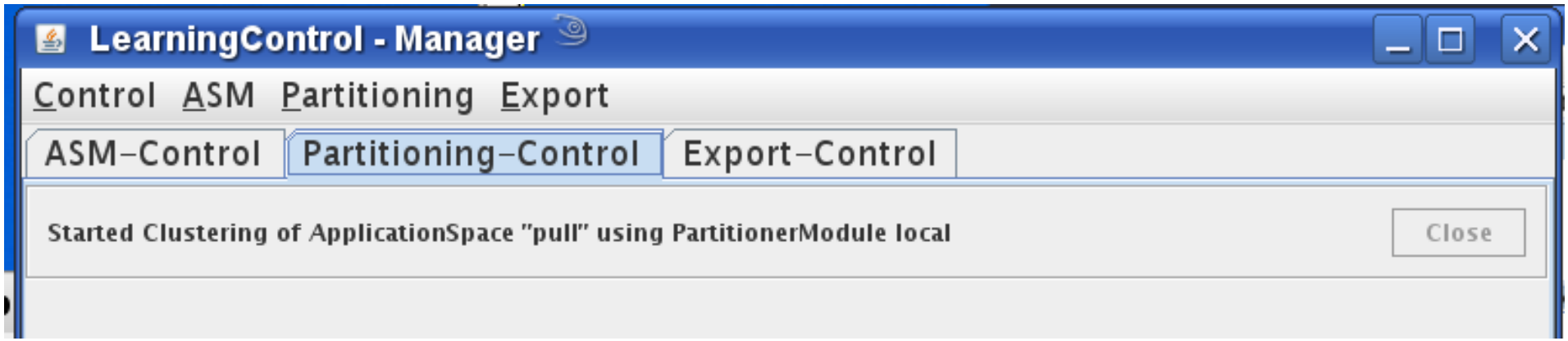


Partitioning
Application Flow



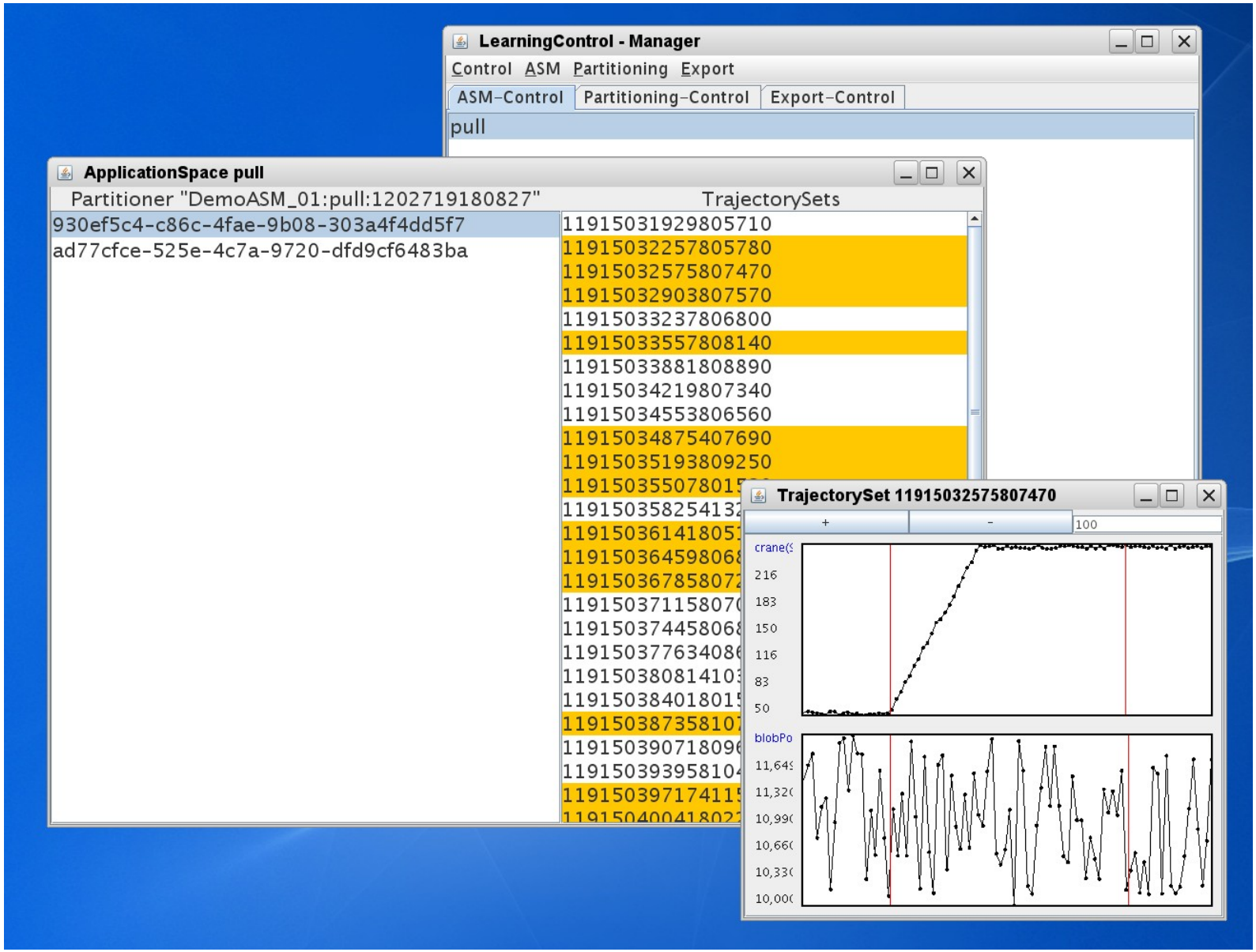
Partitioning

Clustering – Start via GUI



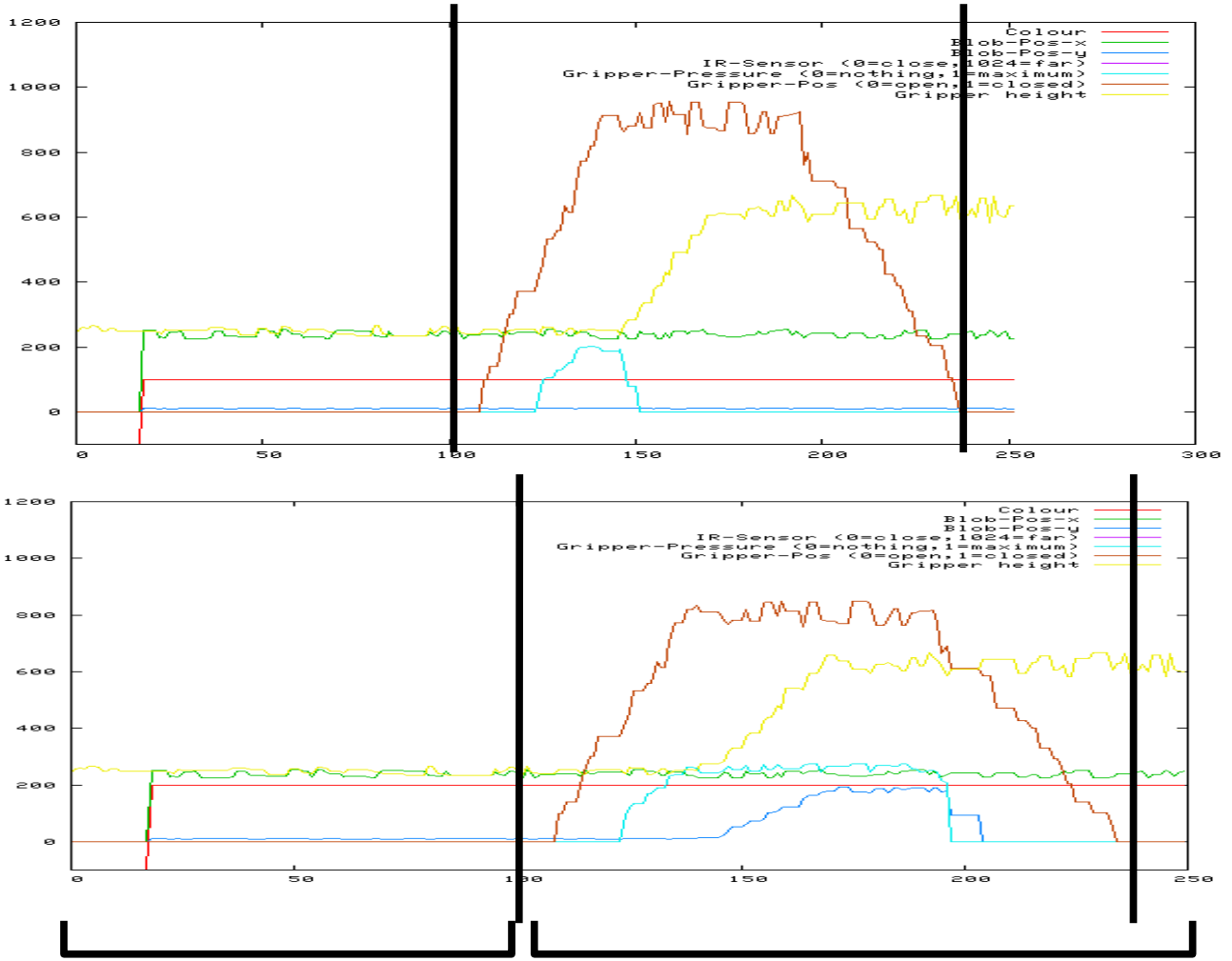
Partitioning

Clustering – Result: Partitioner



Partitioning

Clustering for deriving Outcomes and Cues



Pre-Application-Phase
used for extraction
of relevant cue channels (Step 2a)

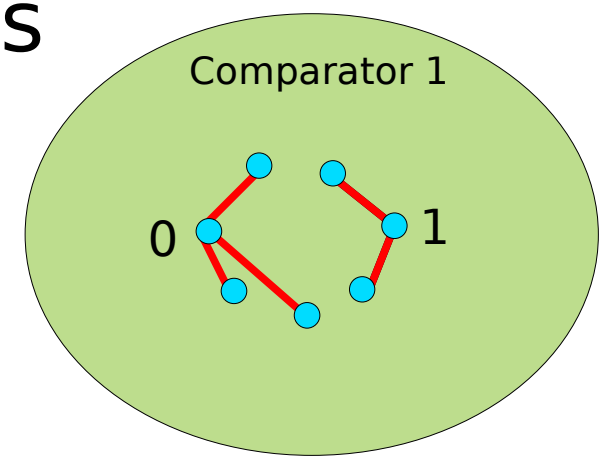
Application- and Post-ApplicationPhase
used for extraction
of relevant outcome channels (Step 3a)

Cue-Learning

- Sub-Partitioning of the Partitioned ApplicationSpaces
- Using the methods developed by JR_DIB Interfaces:
  - File System (storing data with respect to the derived outcome)
  - CORBA-Interface
  - Using the derived Filters

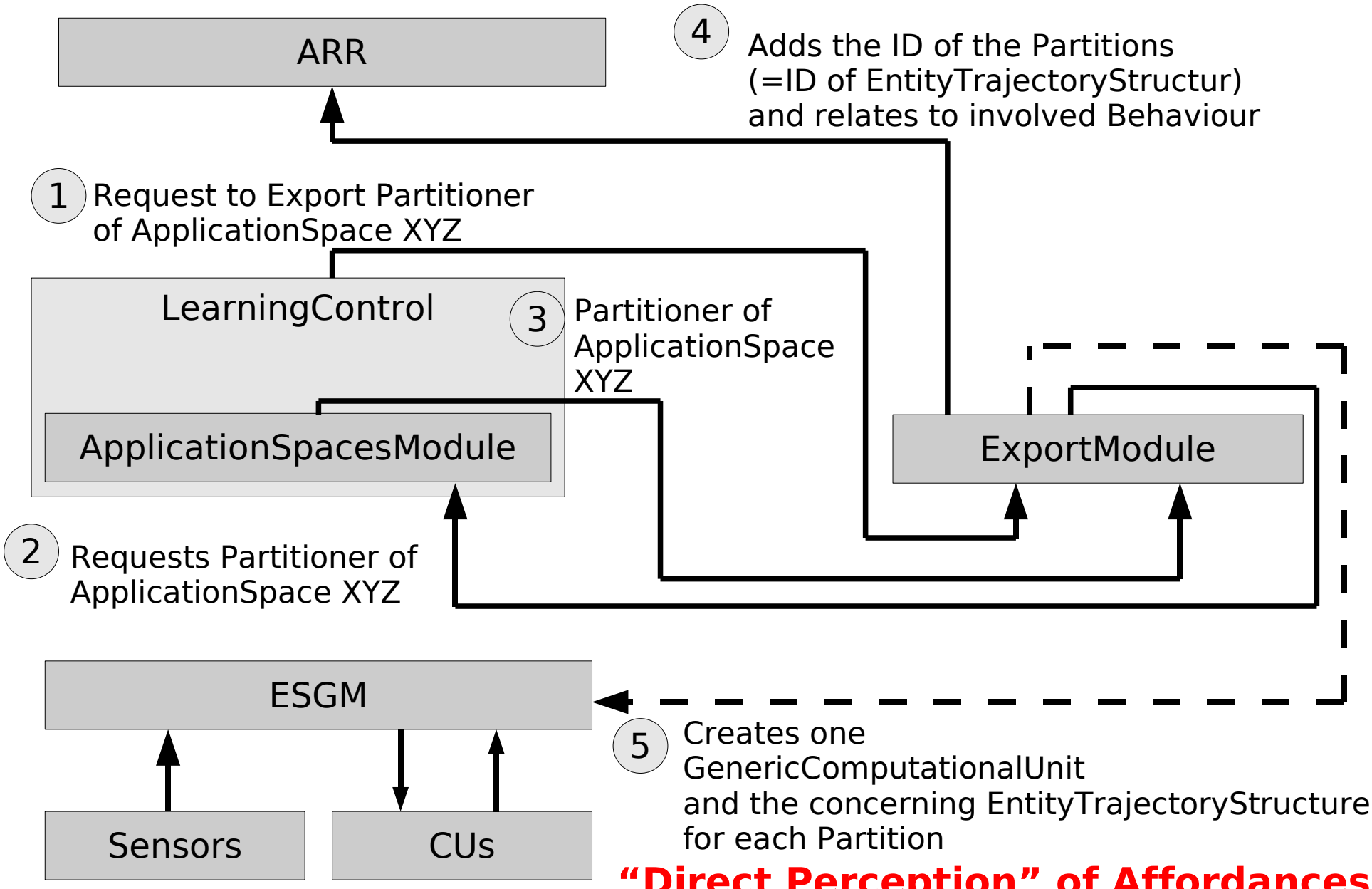
Re-Learning
Adaptation of Networks

- Adaptation of the derived networks
- When a new cluster is found for one channel, the network of the Inter-Channel-Relations must be adapted too
- Implementation via *Listeners* : Data structures representing the inter cluster-relation-graphs are informed when the clusters are changed



Providing the Derived Knowledge

Application Flow – Invocation of ESGM and ARR

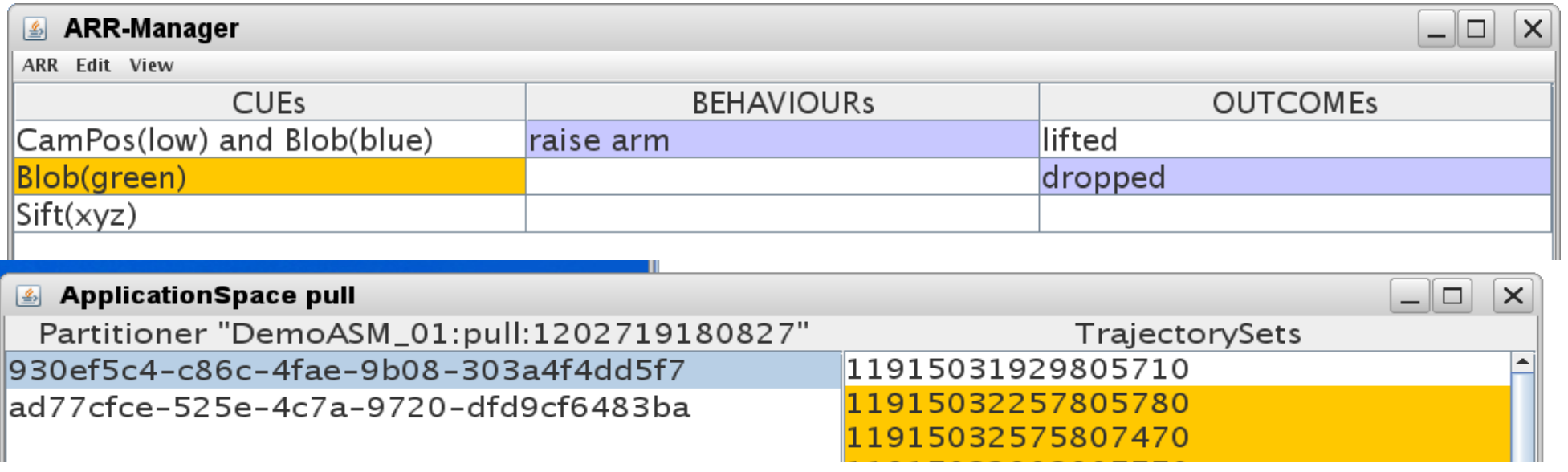


“Direct Perception” of Affordances!

Affordance Representation Repository

ARR-Interface and ARR-GUI

- Stored IDs of the derived Computational Units (CUs) and their Interrelations
- Using these IDs
- Interface via CORBA and RMI
  - to get IDs
  - to query related Cues
- GUI for managing (storing/loading/removing)

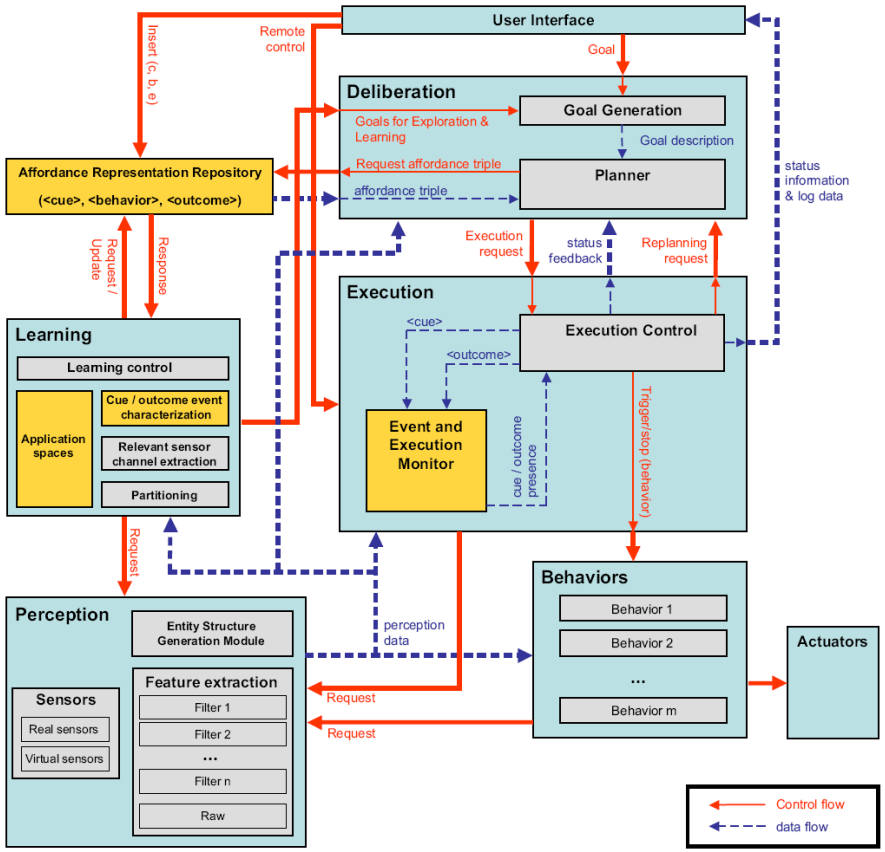


Using the Derived Knowledge

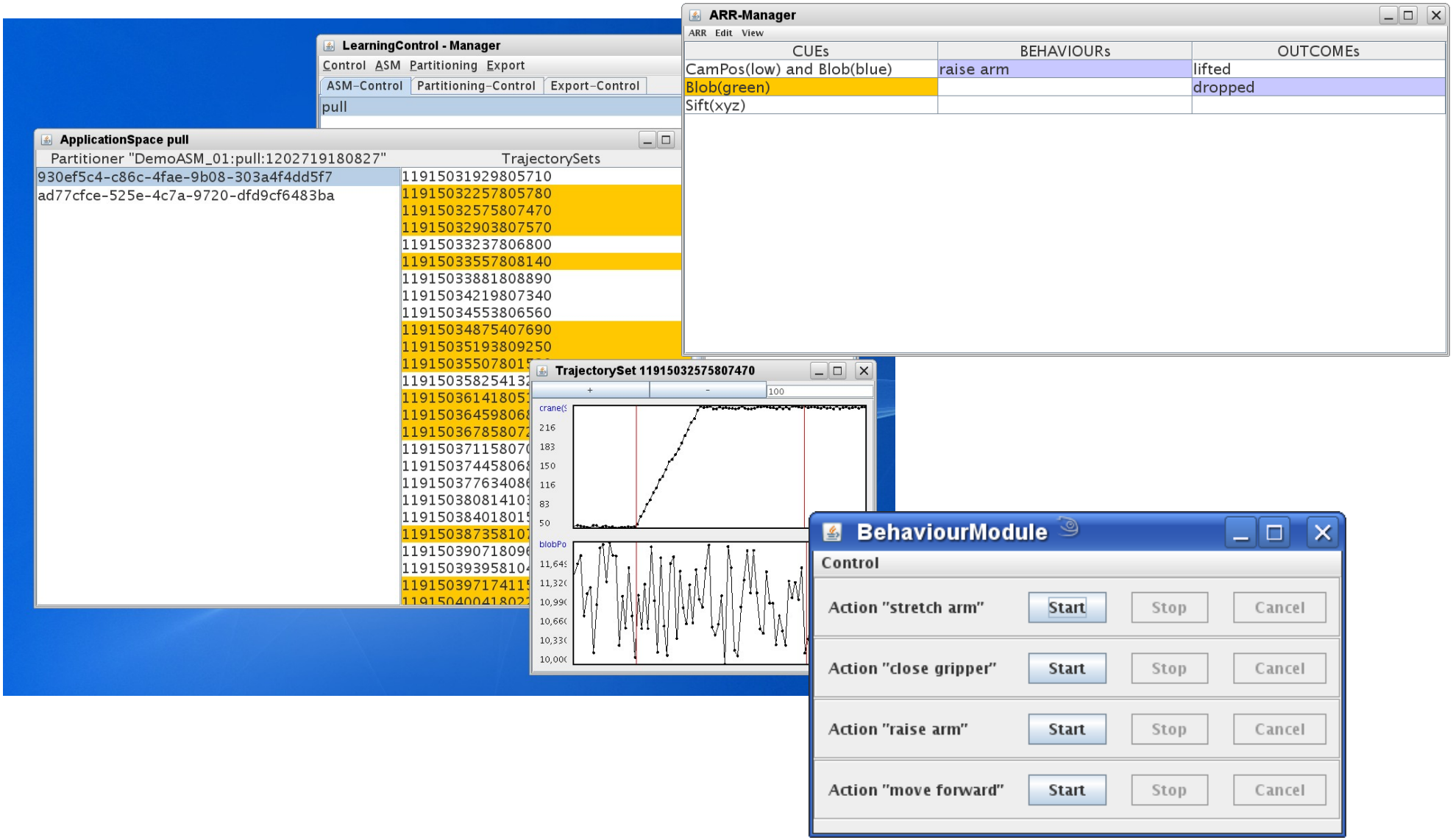
Execution and Planning

Behaviour of agent becomes robust and flexible

- reinforce actions if an Affordance is present
- suppress reflex like actions (don't bite a stone)
- fulfil needs (Hunger etc.)
- accomplish complex missions
- Using the derived knowledge as input for learning enables learning based on Affordances

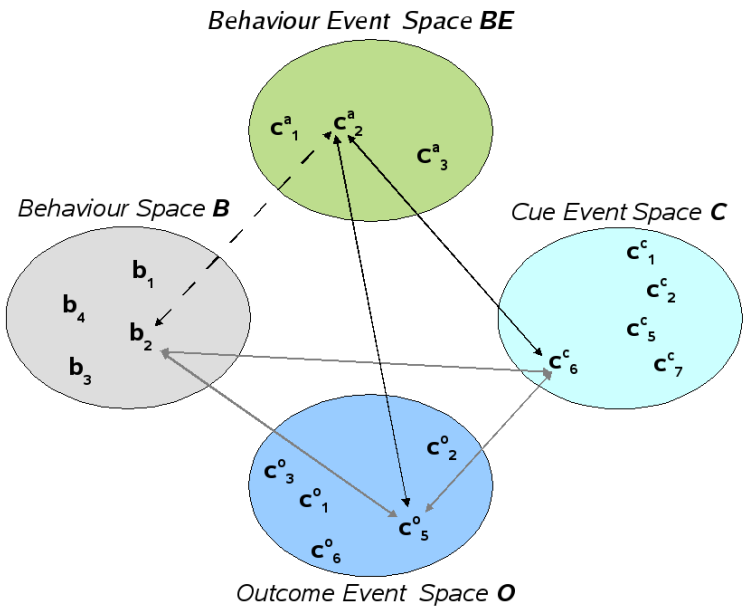


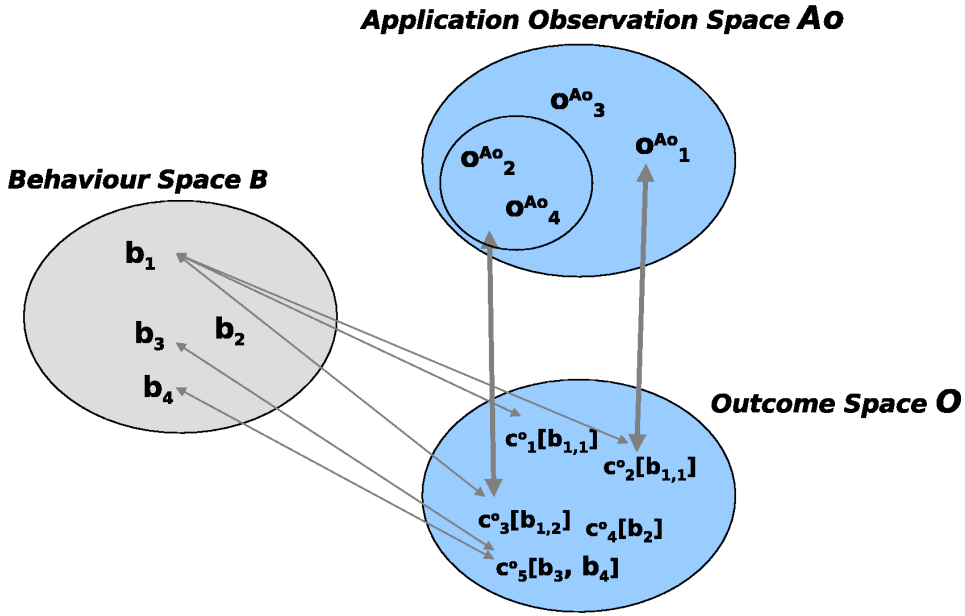
Demonstration
Afternoon



D5.4.5 - Outlook
Learning by Observation

- Learn to detect Behaviours by matching observations to already known Outcomes
- Imitation of Outcomes/Behaviours, not detailed action imitation
- New Cues can be learned without interactions
- Observing Cues and detecting Behaviours can be used to learn new Outcomes.
- Hypotheses must be verified by self-experience





Outlook

Ongoing Development of Software

- Hibernate (for a standardised data storage)
- Maven (for the building process also without Eclipse)
- Increase the Test-Coverage
- Divide Clustering into two independent Modules
- Add Alternatives to ESGM and more Comparators
- Add Software to support Learning by Observation
- GUI components to visualise the learning process
- ...

Thank you!