Soar-EpMem Tutorial
Soar Workshop 30

Nate Derbinsky

University of Michigan

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Topics

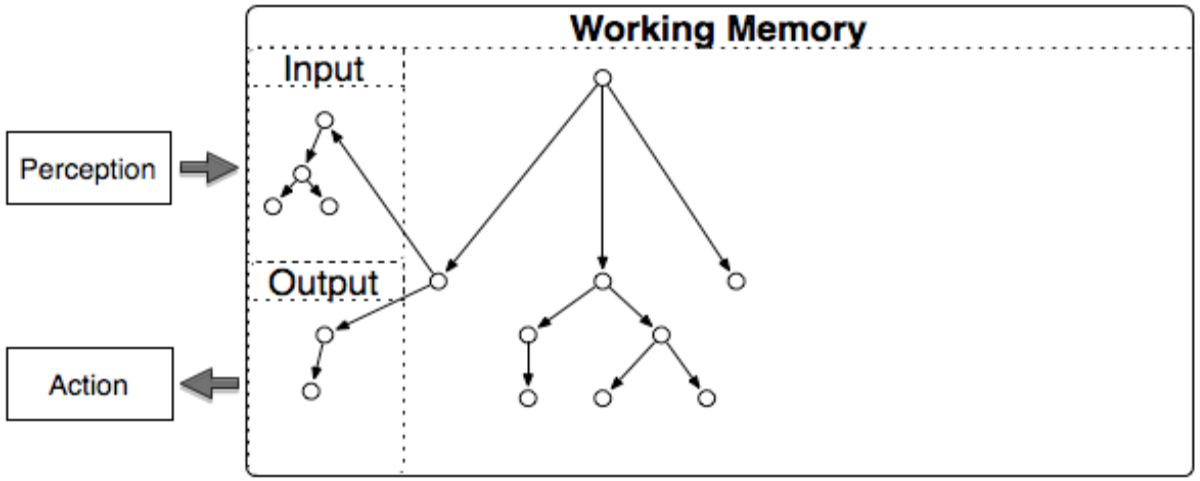
- Big picture
- Demo
- Basic usage
- Additional resources

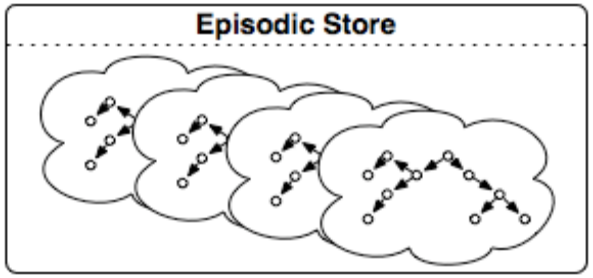
Big Picture

Episodic memory is a weak learning mechanism

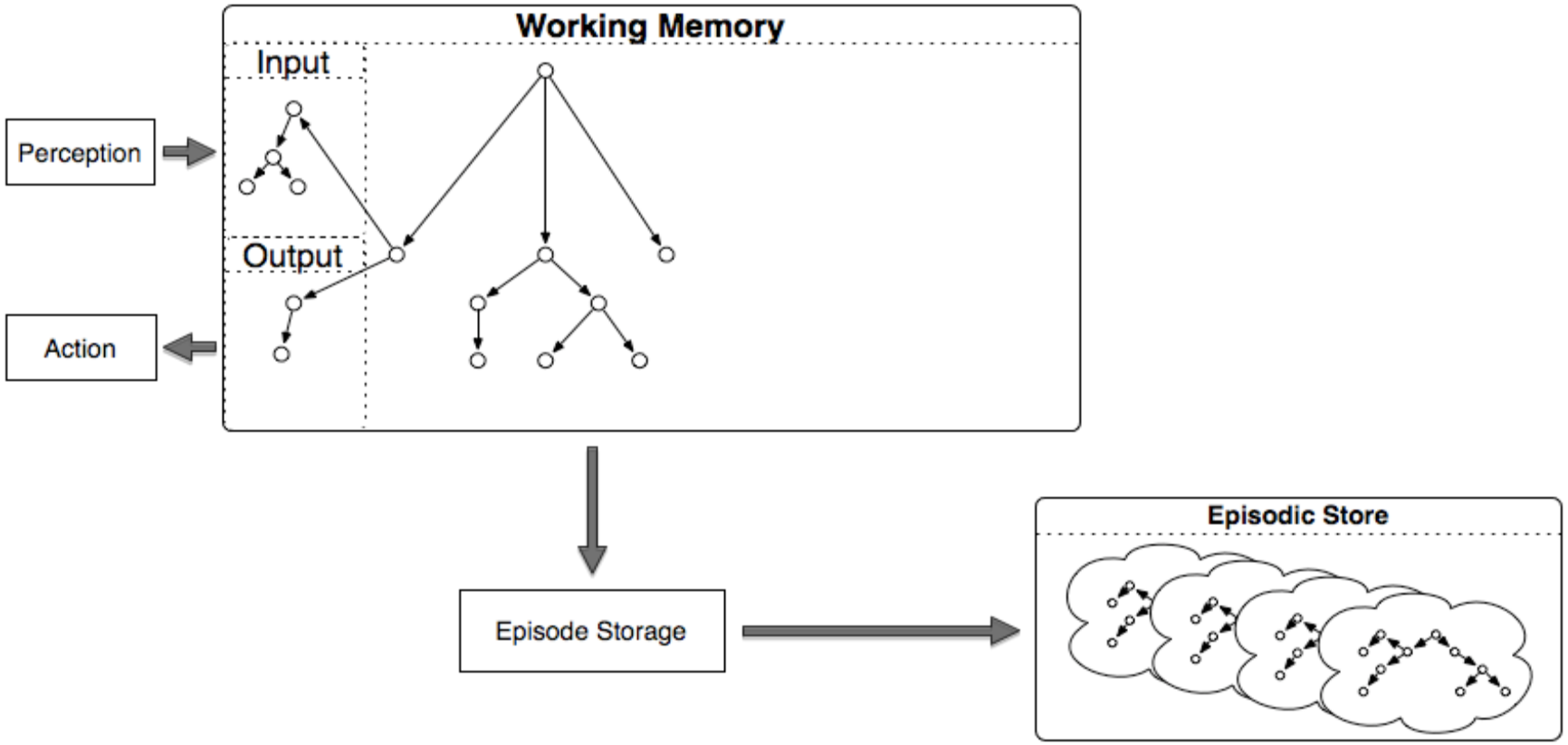
- Automatically stores and temporally indexes agent state
- Supports an *efficient,* content-addressable agent interface to auto-biographical prior experience

Episodic Operations

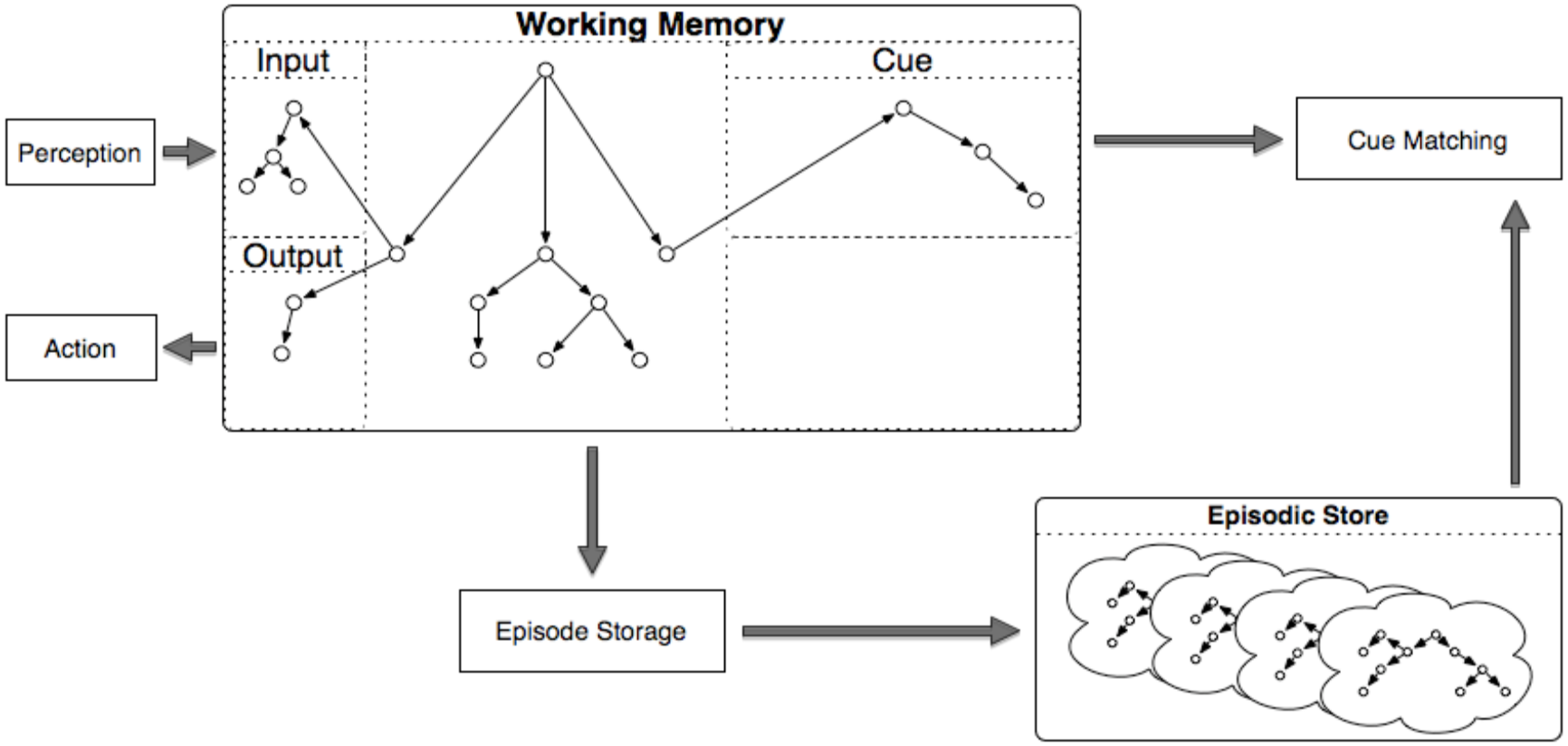




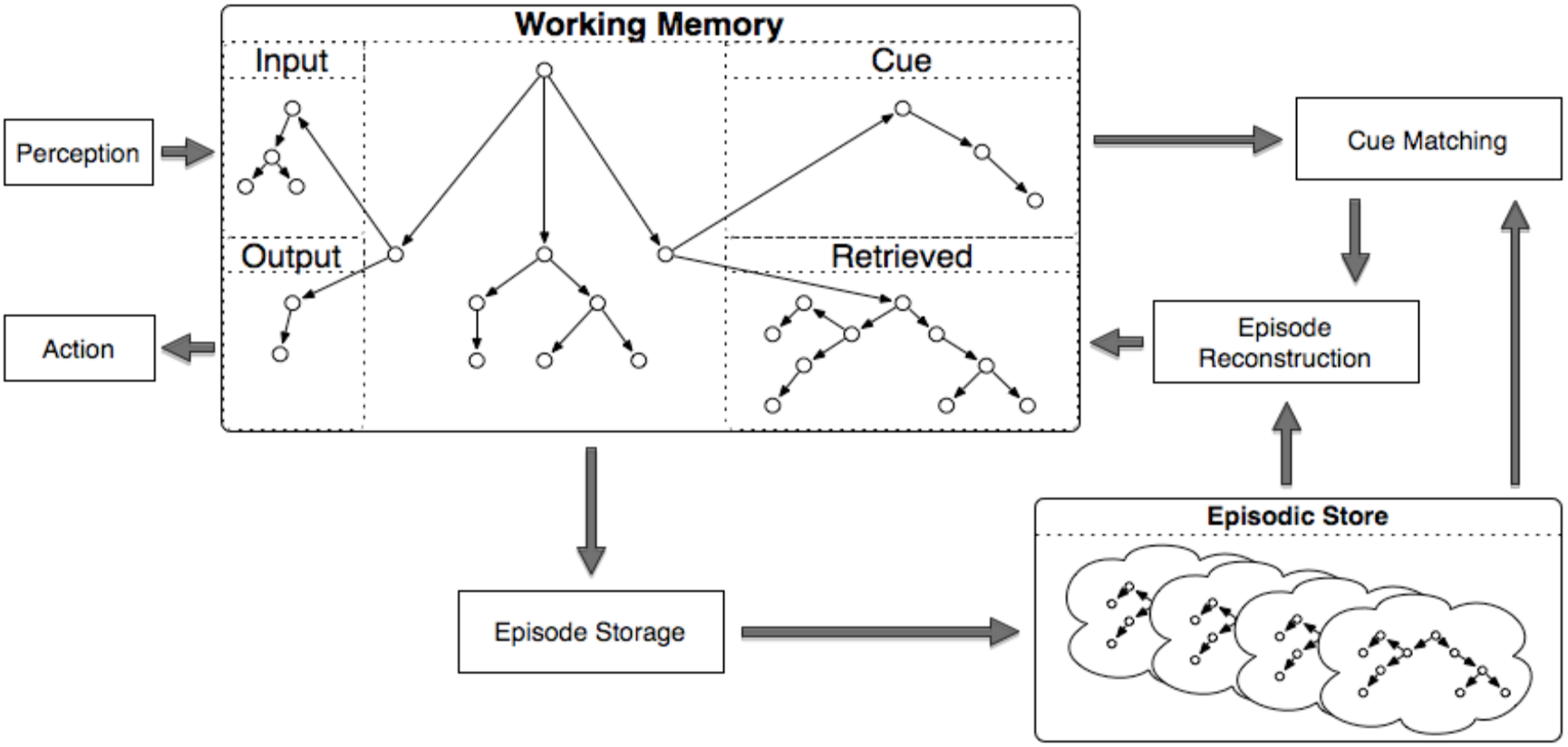
Episodic Operations



Episodic Operations

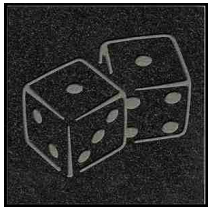


Episodic Operations



Demo Task

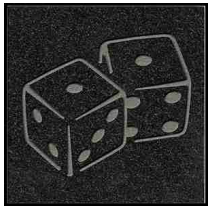
- Produce a random number in WM
  - EpMem automatically records this episode



- Remove the number from WM
  - Write to the trace (for later verification)

- Query episodic memory
  - When did I last see a random number?

- Reason about the retrieved episode
  - Extract and print the number



Produce a Random Number

```
sp {propose*initialize-epmem-rand
   (state <s> ^superstate nil
              -^name)
-->
   (<s> ^operator <o> +)
   (<o> ^name initialize-epmem-rand)
}

sp {apply*initialize-epmem-rand
   (state <s> ^operator <op>)
   (<op> ^name initialize-epmem-rand)
-->
   (<s> ^name epmem-rand
        ^random.num (float (cmd rand)))
}
```

Remove the Number

```
sp {epmem-rand*propose*remember
   (state <s> ^name epmem-rand
              ^random)
-->
   (<s> ^operator <op> + =)
   (<op> ^name remember)
}

sp {apply*remember*cue
   (state <s> ^operator <op>
              ^random <rand>
              ^epmem.command <cmd>)
   (<op> ^name remember)
   (<rand> ^num <num>)
-->
   (write |Removing: | <num>)
   (<s> ^random <rand> -)
   (<cmd> ^query.random <remember-random>)
}
```

Query EpMem

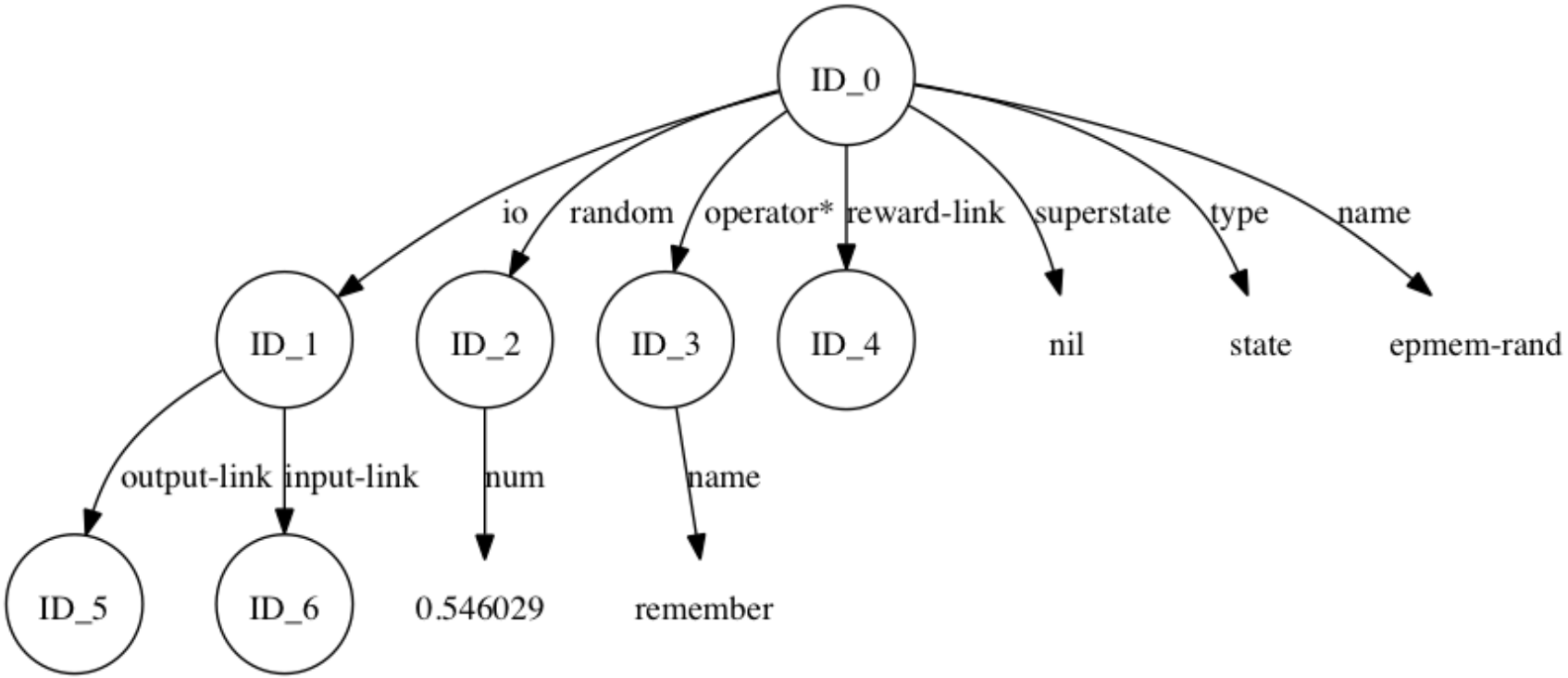
```
sp {epmem-rand*propose*remember
   (state <s> ^name epmem-rand
              ^random)
-->
   (<s> ^operator <op> + =)
   (<op> ^name remember)
}

sp {apply*remember*cue
   (state <s> ^operator <op>
              ^random <rand>
              ^epmem.command <cmd>)
   (<op> ^name remember)
   (<rand> ^num <num>)
-->
   (write |Removing: | <num>)
   (<s> ^random <rand> -)
   (<cmd> ^query.random <remember-random>)
}
```

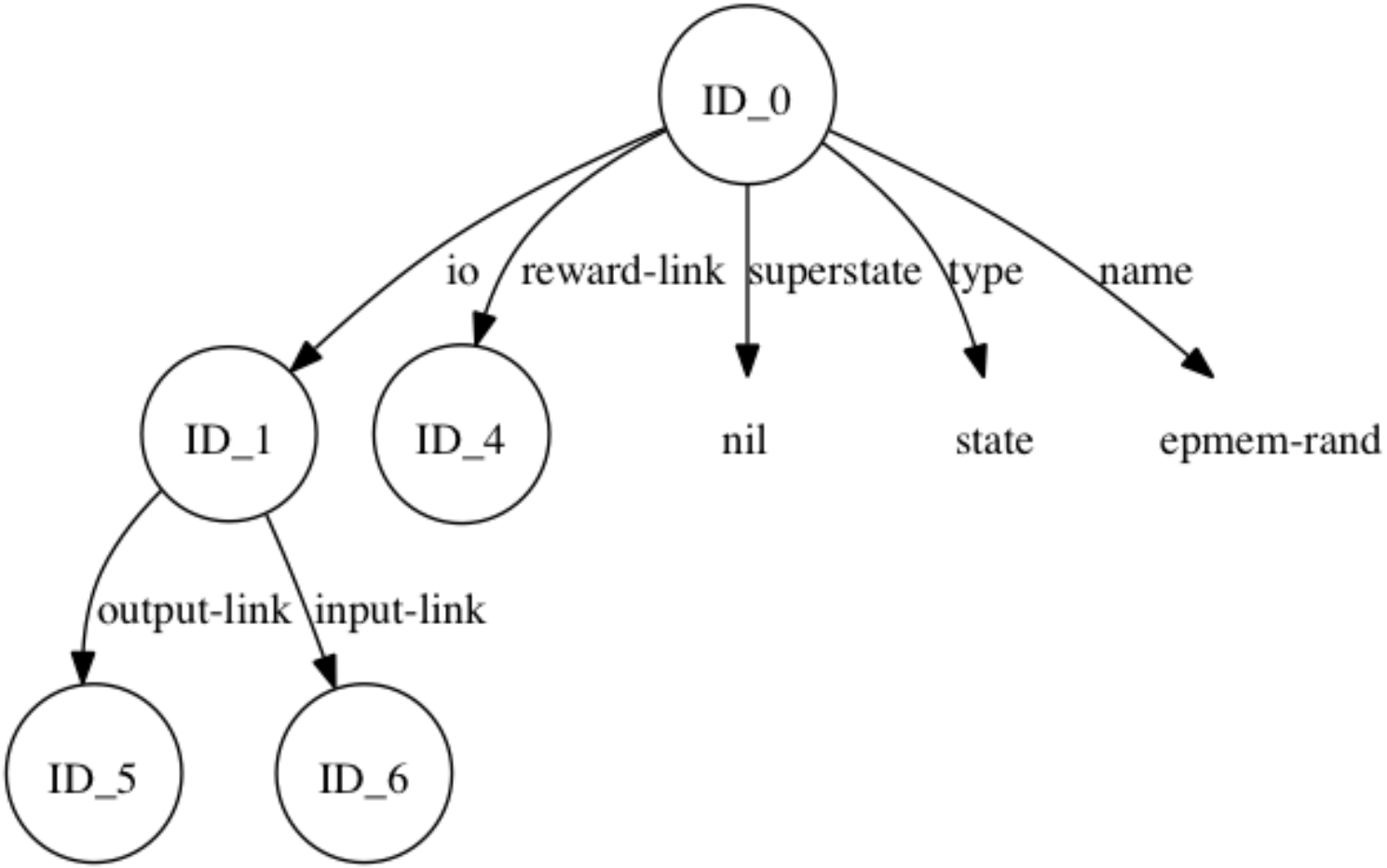
Report Result

```
sp {done
   (state <s> ^epmem.result.retrieved.random.num <num>)
-->
   (write |Remebered number: | <num>)
   (halt)
}
```

Demo Episode 1



Demo Episode 2

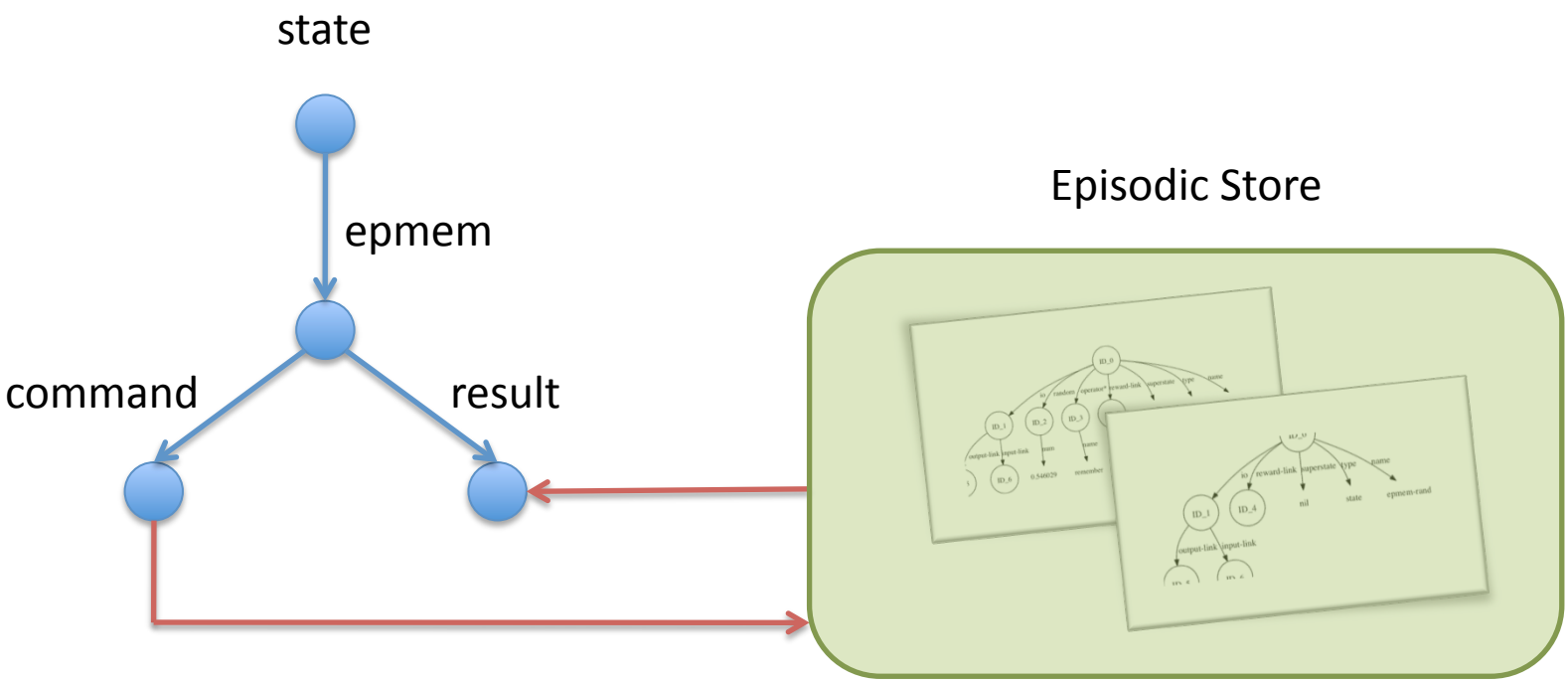


Basic Usage

- Working Memory structure
- Storage
- Retrievals

Working Memory Structure

Agents interact with an **epmem** structure on each state



Episodic Storage

Storage is automatic when EpMem is enabled

```
> epmem --set learning on
```

Events trigger storage of new episodes

```
> epmem --set trigger << dc output >>
```

dc: decision cycle

output: new identifier on output-link (default)

Storage takes place at the end of a phase

```
> epmem --set phase << output selection >>
```

output is default

EpMem captures the top state of working memory

Retrieving Knowledge

Command Types

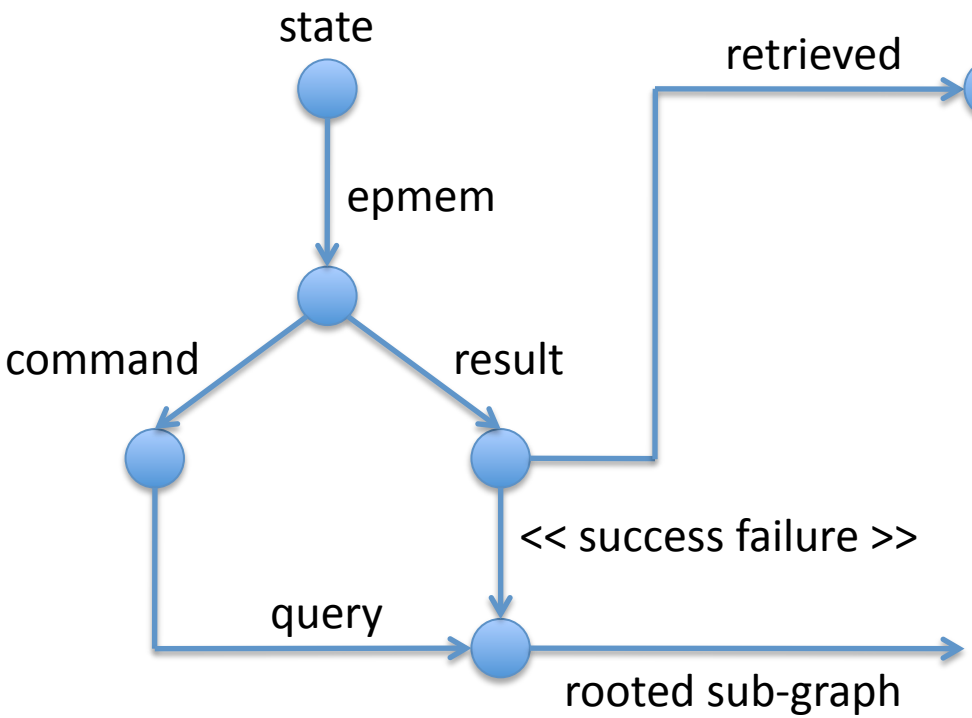
- Cue-Based (content-addressability)
- Temporal progression
- Non-Cue-Based

Notes

- Only one per state, per decision

Cue-Based Retrievals

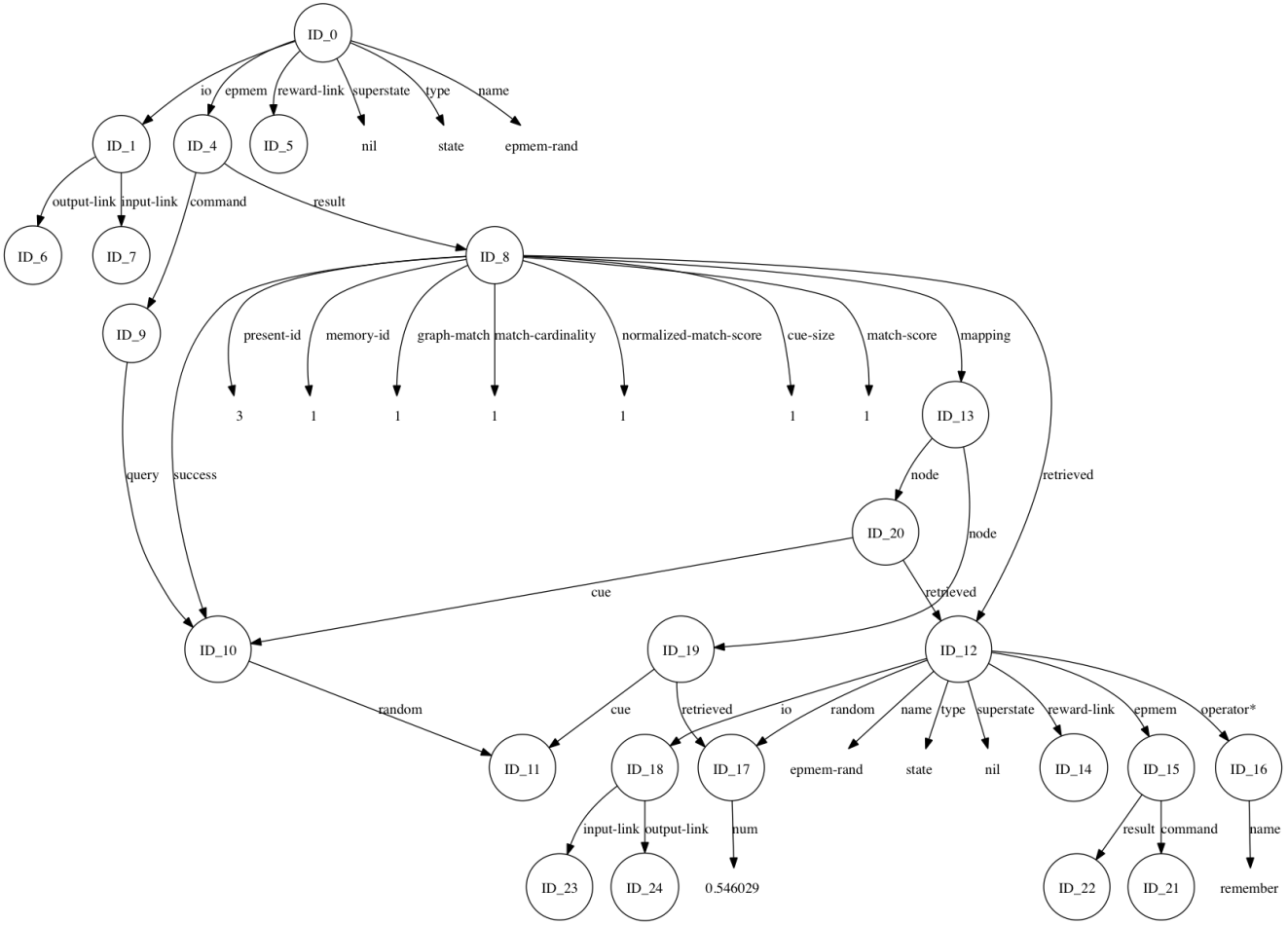
Acyclic graph rooted at **query** identifier forms contextualized soft constraint(s) of the top state of the retrieved episode (ties broken by storage recency)



WME Values

Constant	Exact match
Long-Term ID	Exact match, stop
Short-Term ID	Wildcard ID

Example Retrieval Result



Other Retrievals

Temporal progression

```
state.epmem.command.next <n>
state.epmem.command.previous <p>
```

Non-Cue-Based

```
state.epmem.command.retrieve <episode #>
```

Useful Commands

```
> watch --epmem
```

Graphviz

```
> epmem [v|--viz] <episode #>
```

Save episodic store to disk (SQLite3)

```
> epmem --set path /path/to/file.db
```

Additional Resources

- Soar-EpMem Documentation
- Soar-EpMem Demos
- Readings

Soar-EpMem Documentation

Manual

$SOAR_HOME/share/soar/Documentation

- Topics
  - Additional storage/retrieval details
  - Performance
  - Working Memory Activation
  - Usage: commands, parameters, statistics, etc.

Soar-EpMem Demos

KB (Knowledge Base)

$SOAR_HOME/share/soar/Demos

– Unit tests that use most of agent retrieval API

Readings

2004

- A Cognitive Model of Episodic Memory Integrated with a General Cognitive Architecture
  Andrew M. Nuxoll, John E. Laird (ICCM)

2007

- Extending Cognitive Architecture with Episodic Memory
  Andrew M. Nuxoll, John E. Laird (AAAI)
- Enhancing Intelligent Agents with Episodic Memory
  Andrew M. Nuxoll (Dissertation)

2009

- Efficiently Implementing Episodic Memory
  Nate Derbinsky, John E. Laird (ICCBR)
- A Year of Episodic Memory
  John E. Laird, Nate Derbinsky (IJCAI Workshop)
- Learning to Use Episodic Memory
  Nicholas A. Gorski, John E. Laird (ICCM)

2010

- Extending Soar with Dissociated Symbolic Memories
  Nate Derbinsky, John E. Laird (AISB)
- Instance-Based Online Learning of Deterministic Relational Action Models
  Joseph Xu, John E. Laird (AAAI)