# *Formal Methods for Interactive Systems*

Part 6 — Cognitive Models

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# *Analysis of Interactive Systems*

Purposes:

- Understand the internal cognitive processes of a person performing a task
  $\Longrightarrow$ analyse complexity, learnability, ...

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- Understand the internal cognitive processes of a person performing a task
  $\Longrightarrow$ analyse complexity, learnability, ...
- Look at the observable behaviour of a person performing a task
  $\Longrightarrow$ analyse requirement capture, interface design, system design, documentation

# *Cognitive Models*

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- goal and task hierarchies: GOMS, Cognitive Complexity Theory (CCT)
- human understanding: BNF, Task-action Grammar (TAG)
- physical/device: Keystroke-level Model (KLM)

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$\Longrightarrow$ need for meta-model, expressive and flexible and able to address perfomance and be instantiated as overall system model

# *Formal Methods*

- Z and B
- Statecharts
- Petri nets
- Process Algebras
- Temporal Logic
- ...

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- address safety and security standards

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**Action** to be performed as a series of interaction with the interface.

# *OCM for Nuclear Plant*

**Scanning:** The operator scans among each of the individual reactor readouts on the interface searching for any anomalies.

**Identification:** The operator identifies a particular readout.

**Classification:** The operator

- assesses whether the identified readout describes a normal or abnormal operation of the plant;
- if abnormal, gives a priority to the operation according to its urgency to be resolved.

**Decision** on how to resolve the abnormal situation.

**Action** to be performed as a series of interaction with the interface and with internal and/or external authorities.

# *OCM for Air Traffic Control*

**Scanning:** The operator scans among each pair of aircraft searching for a pair that may violate separation.

**Identification:** The operator identifies a pair of aircraft.

**Classification:** The operator

- assesses whether the identified pair of aircraft will eventually violate separation (in conflict) or not (not in conflict);
- if so, gives a priority to the conflict according to its urgency to be resolved.

**Decision** on how to resolve the conflict.

**Action** to be performed as a series of interaction with the interface.

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# *Scanning*


Scan:
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# *Identifying Part*

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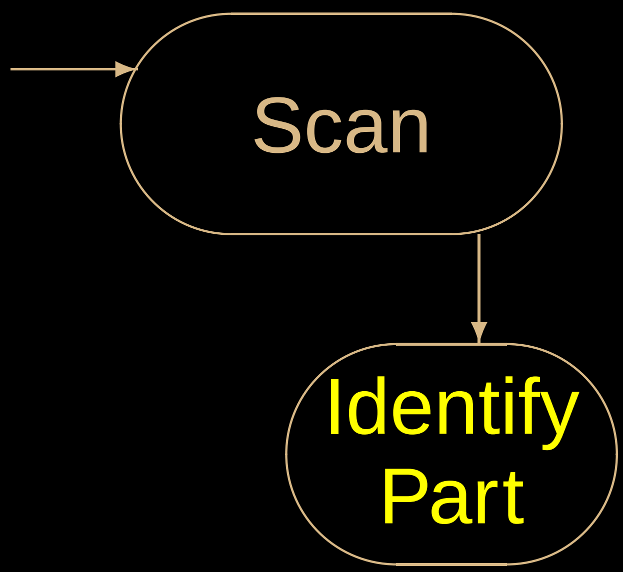


Identify Part:
The operator identifies a part $p$ of the interface that may represent the property of interest.

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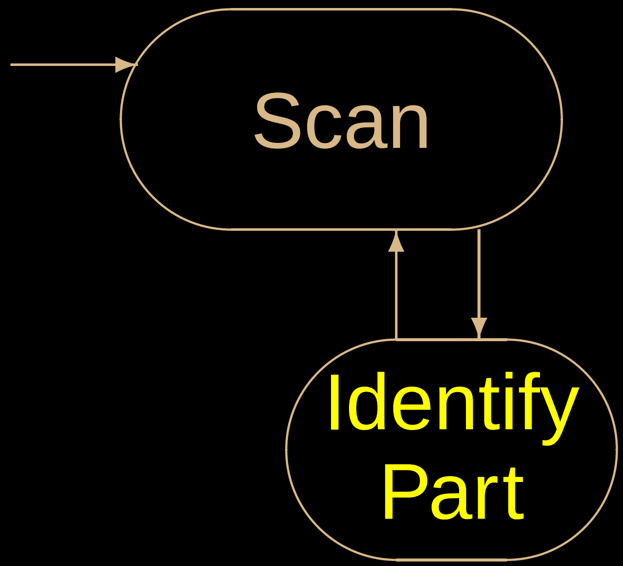


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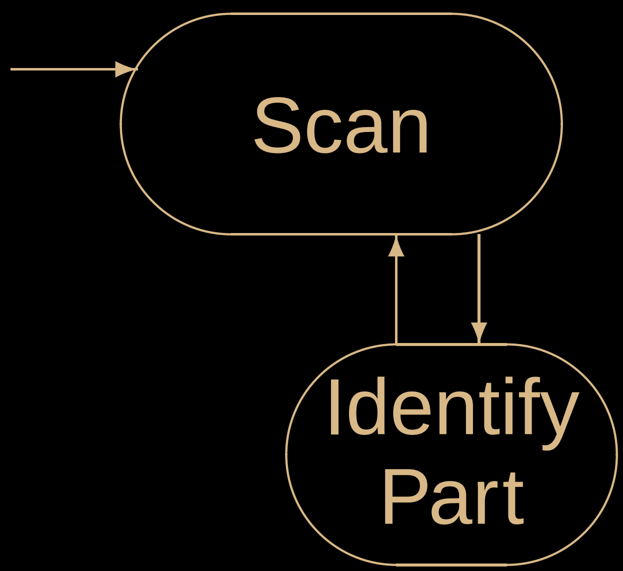

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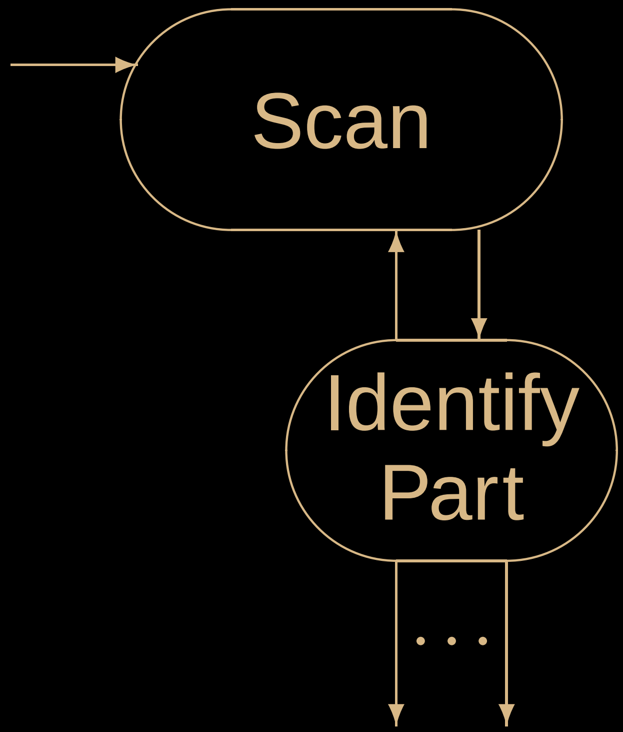

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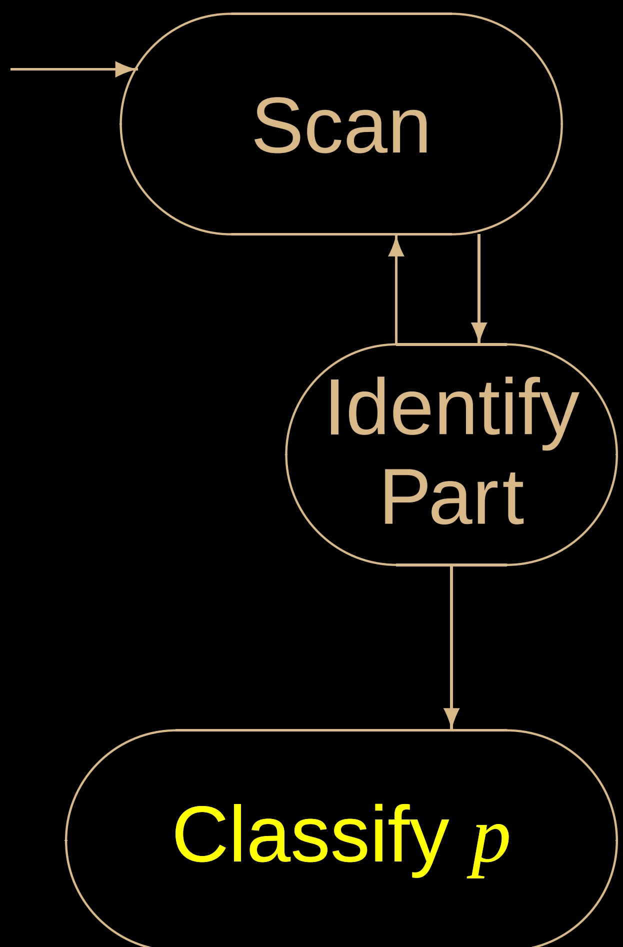


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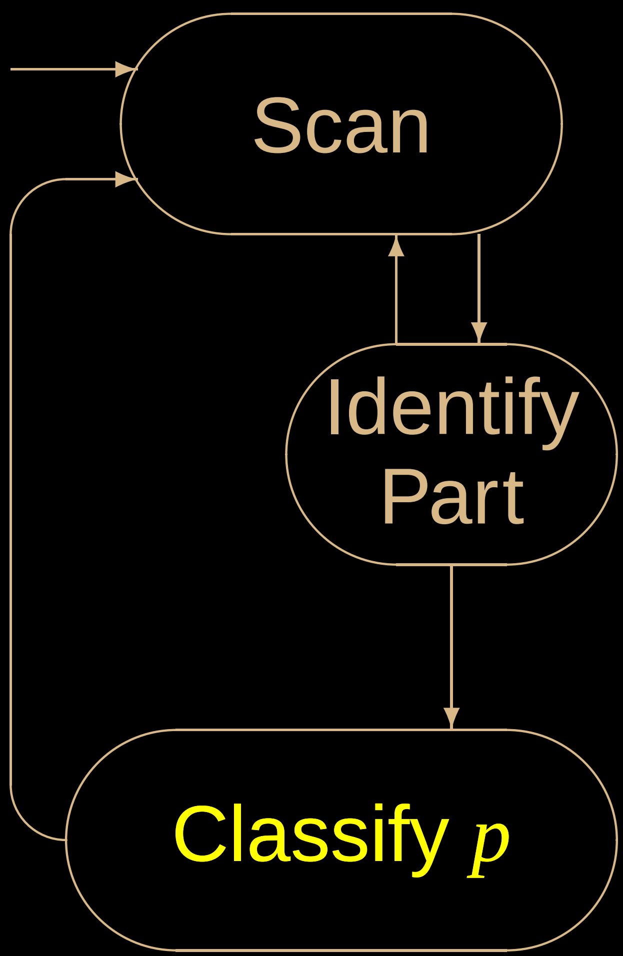


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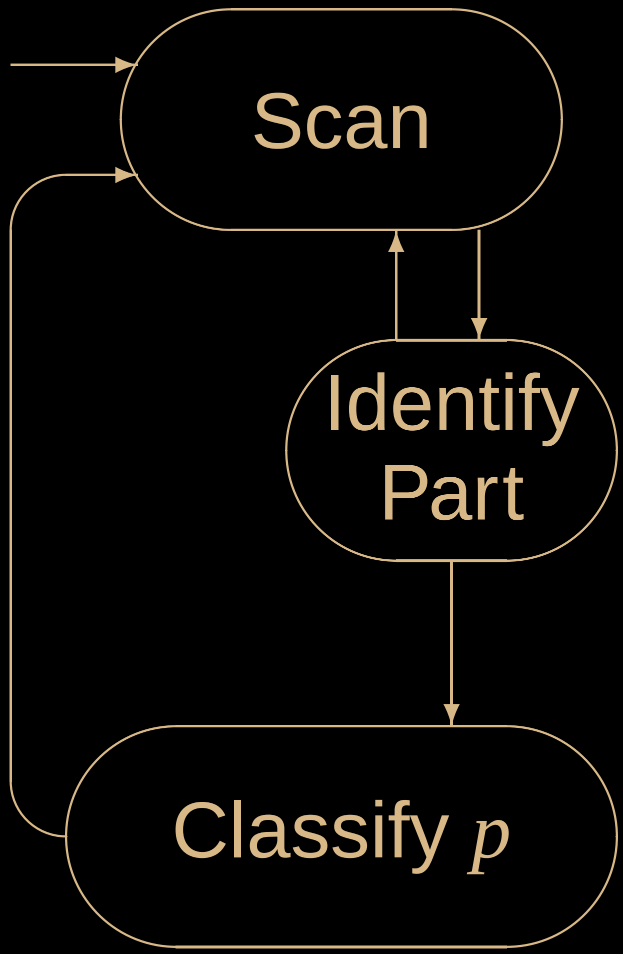

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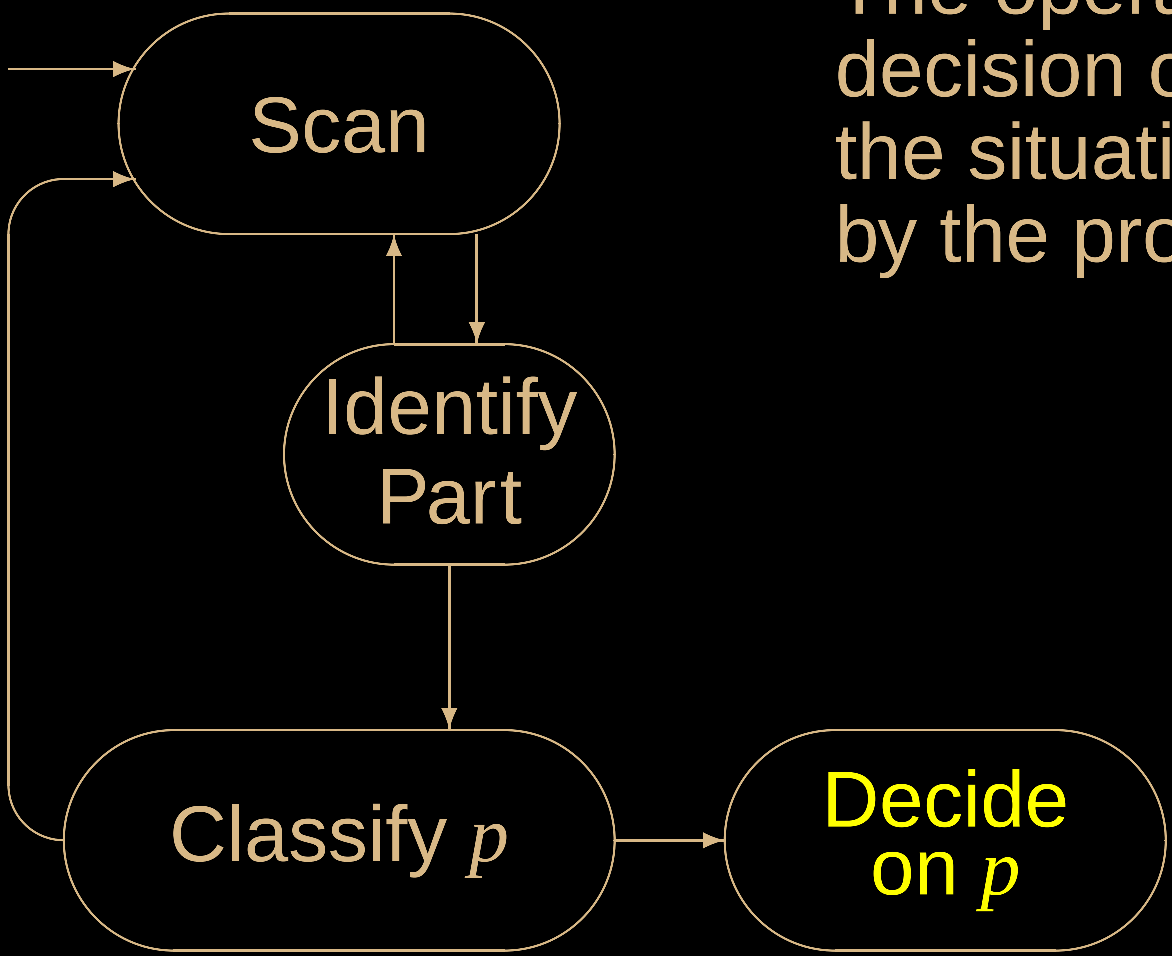


Make Decison on $p$:
The operator makes a decision on how to resolve the situation determined by the property of $p$.

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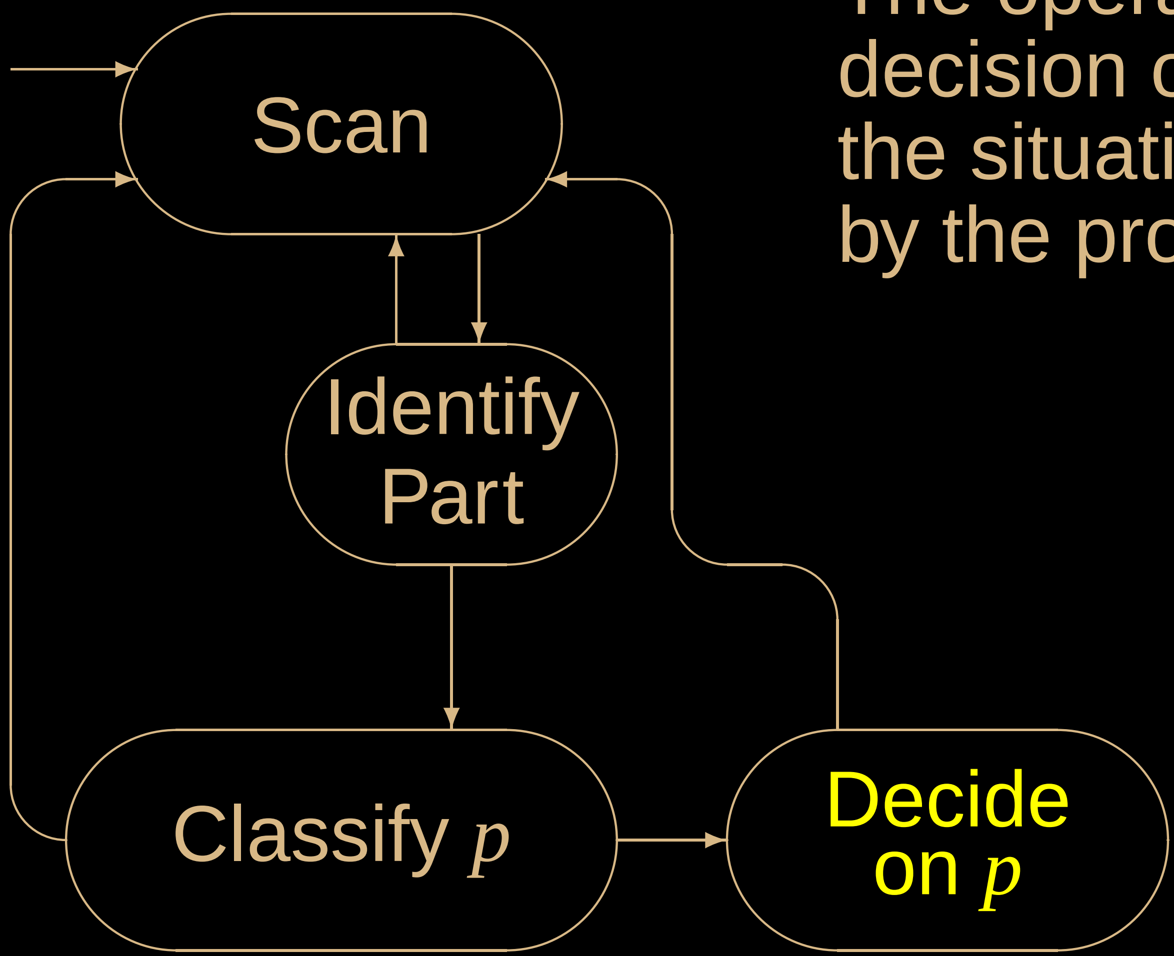


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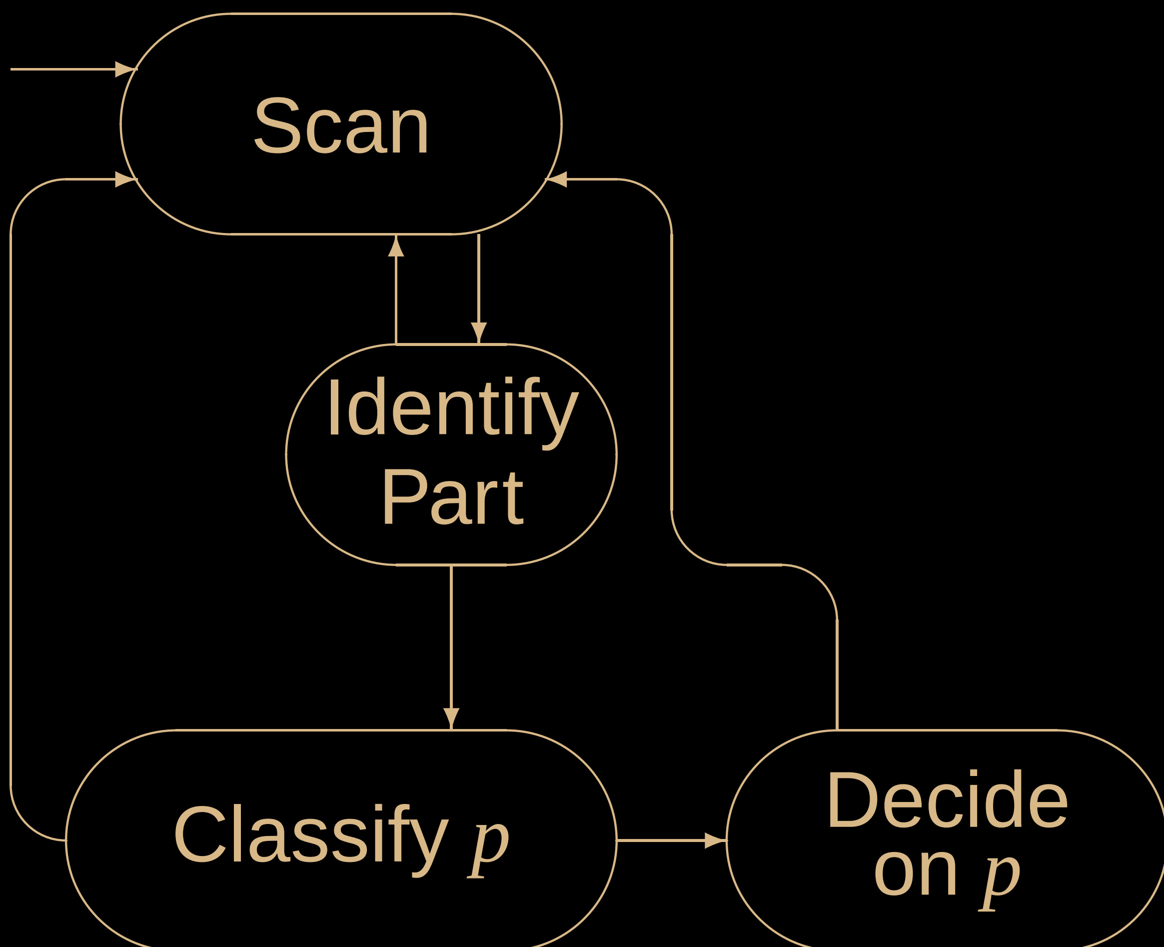
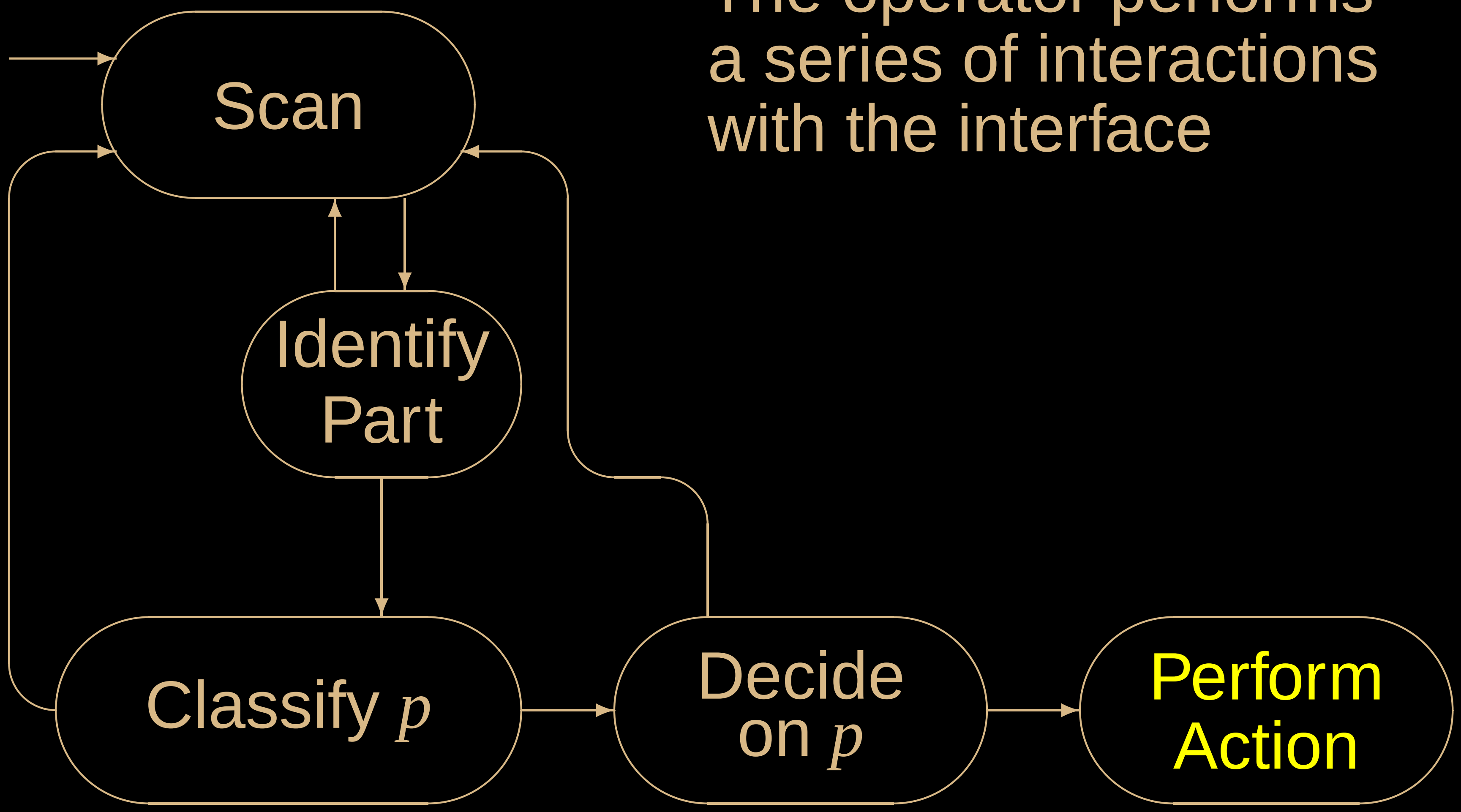


# *Action*

Perform Action:
The operator performs a series of interactions with the interface



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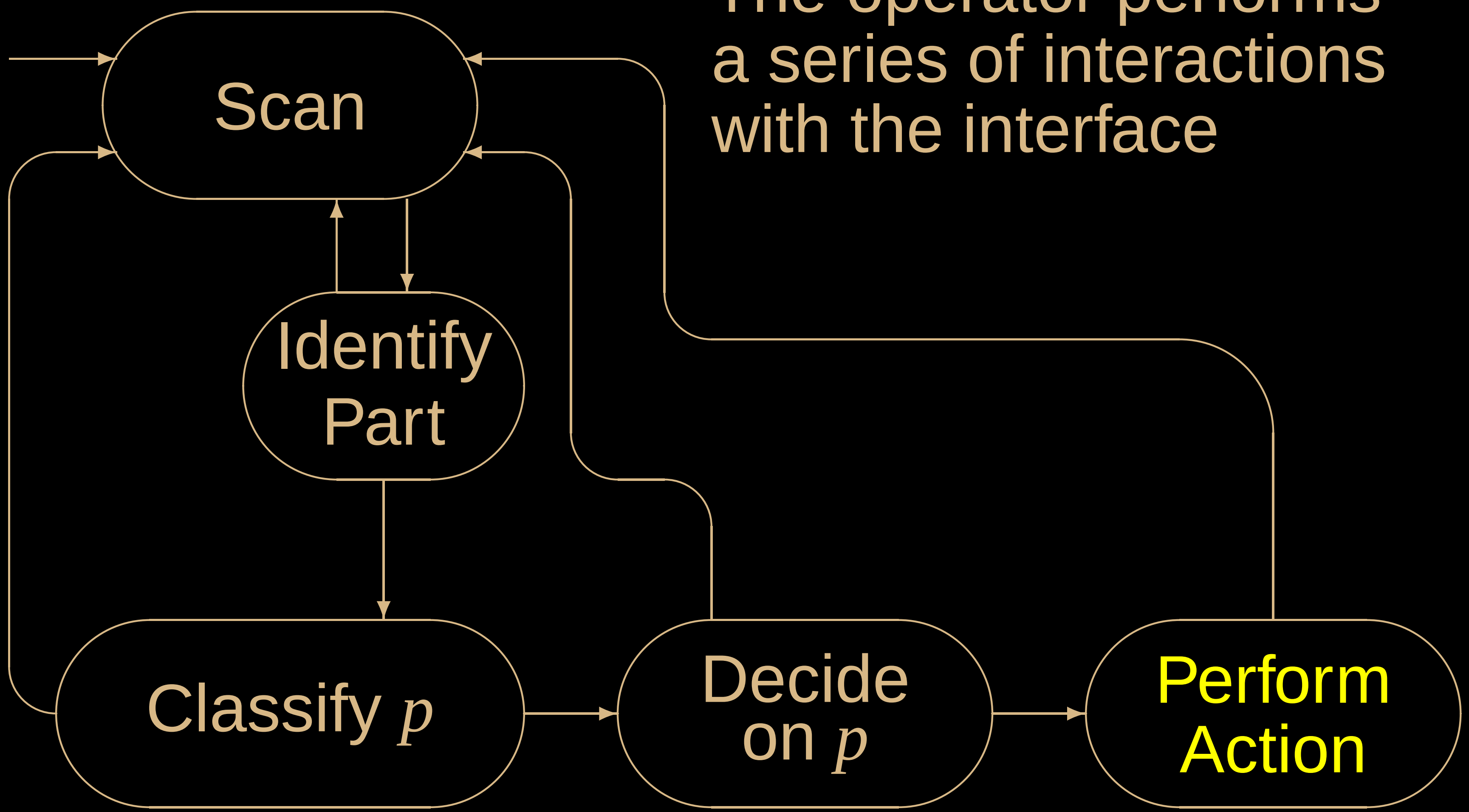


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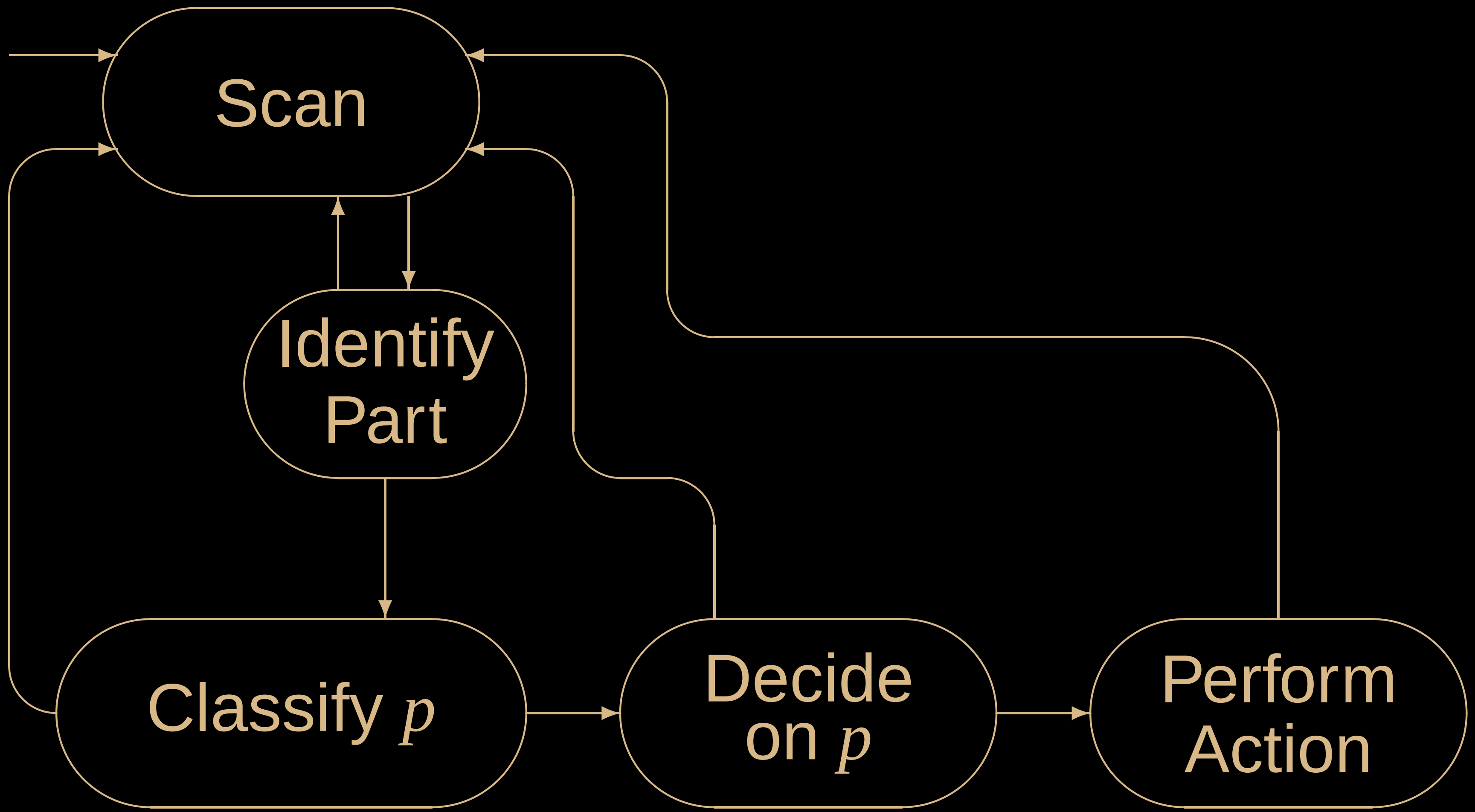
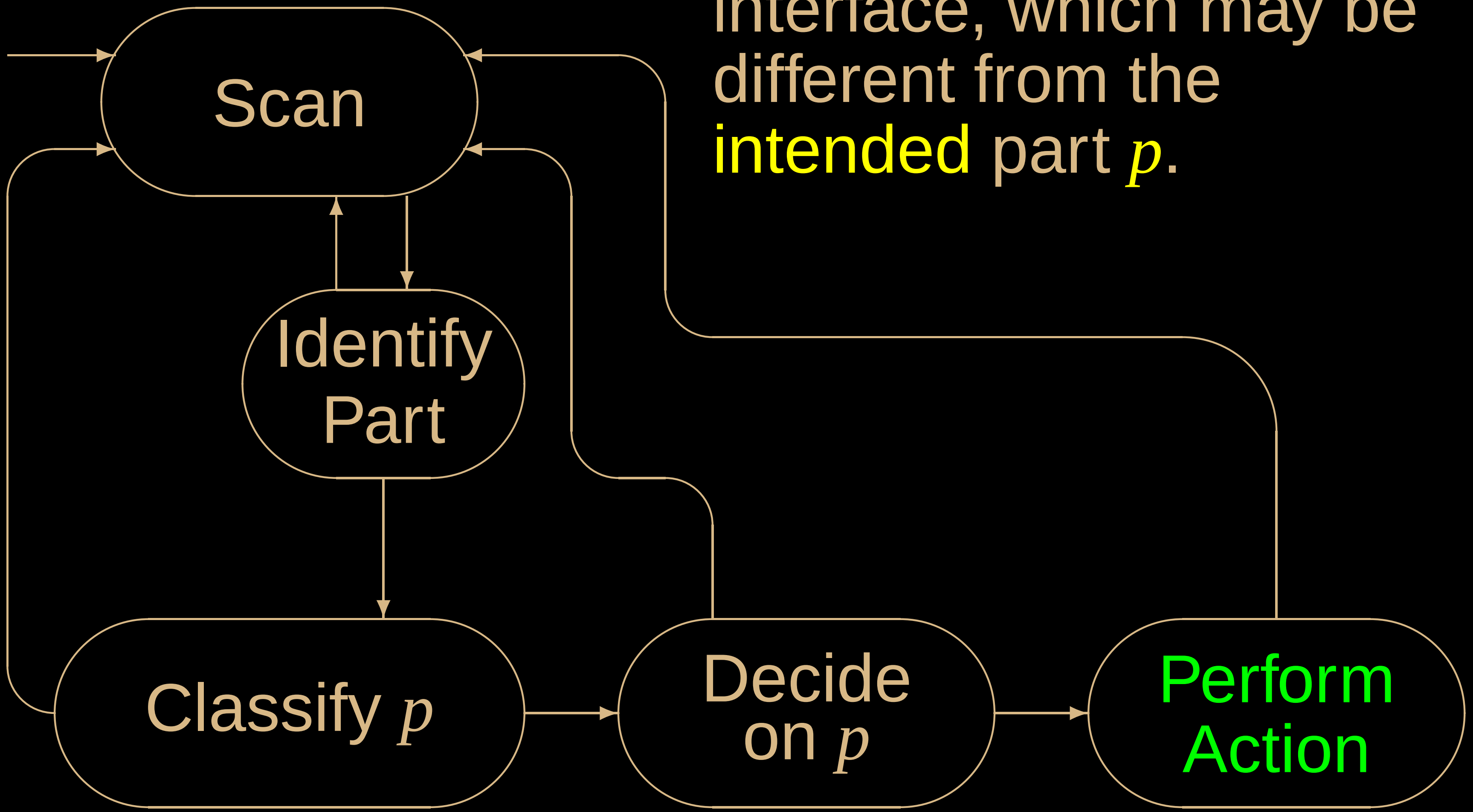
# *Intention vs. Action*



# *Intention vs. Action*

The Action is performed on the selected part of the interface, which may be different from the intended part $p$.



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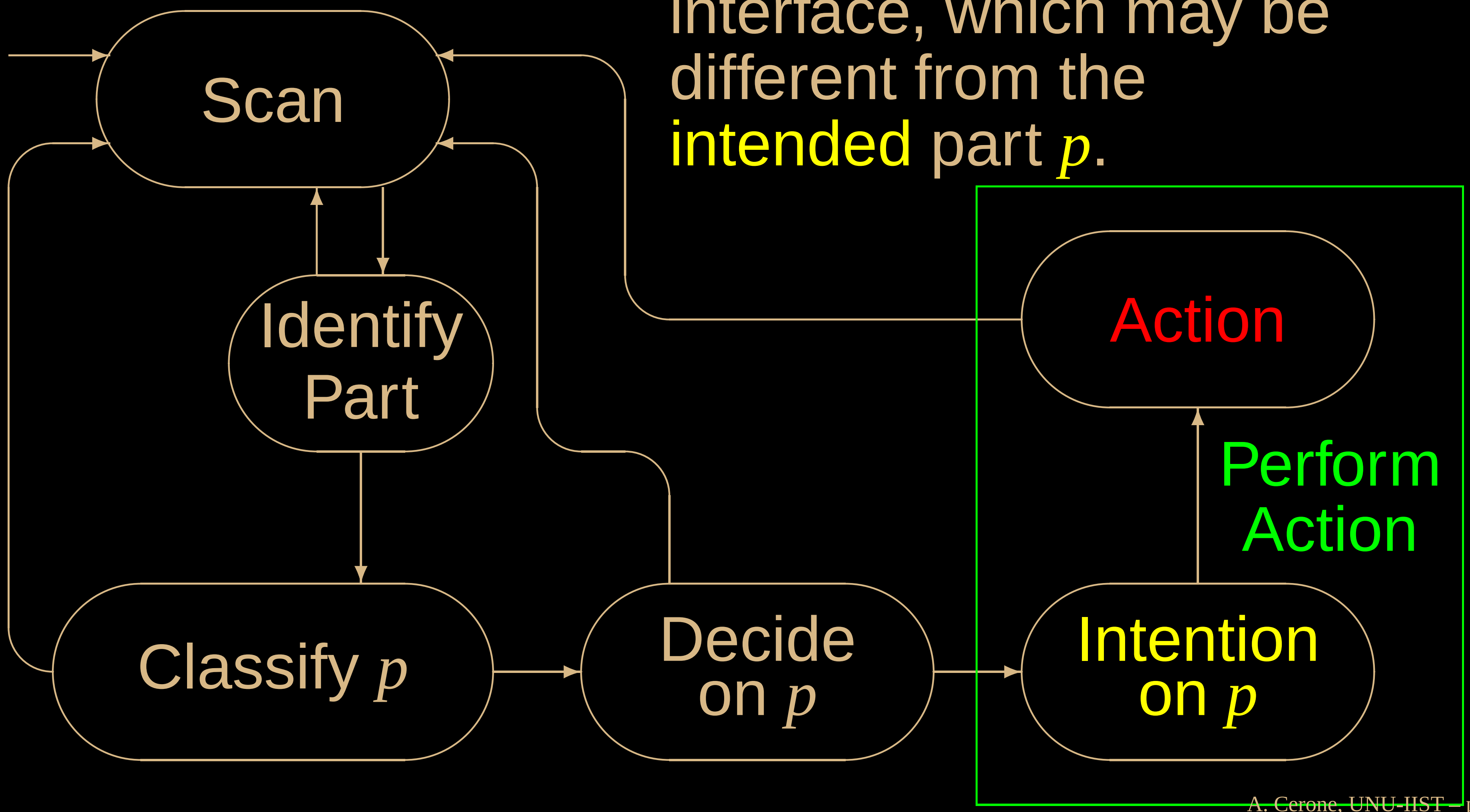

# *CSP Notation*

Communication Sequential Processes

Actions: $a$, $b$, $c$, ...

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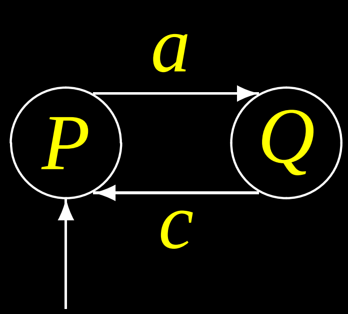

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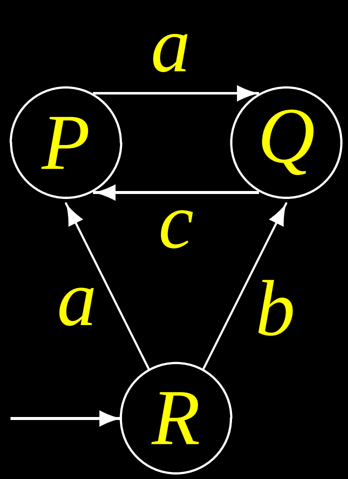
Choice: $\Box$ $\qquad$ $R = (a \rightarrow P) \Box (b \rightarrow Q)$



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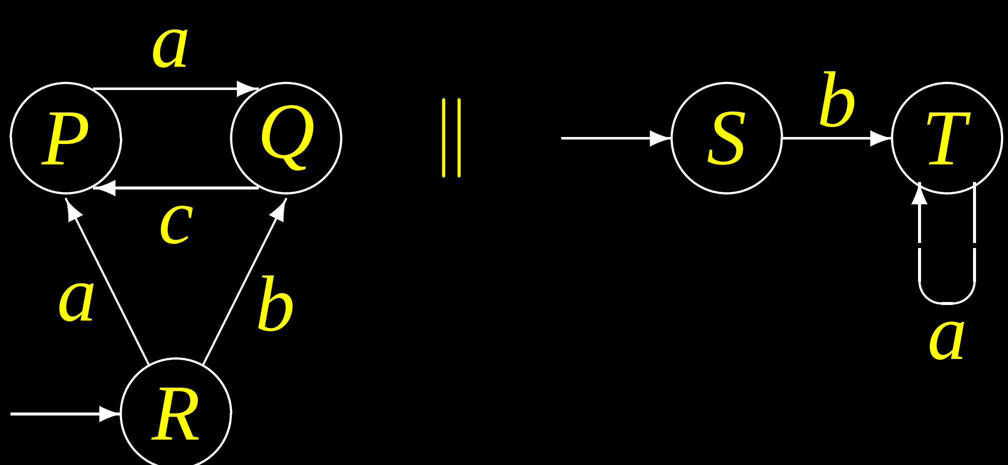
Choice: $\Box$ $\quad R = (a \rightarrow P) \Box (b \rightarrow Q)$

Parallel: $\parallel$ $\quad R \parallel S, \quad S = b \rightarrow T, \quad T = a \rightarrow T$



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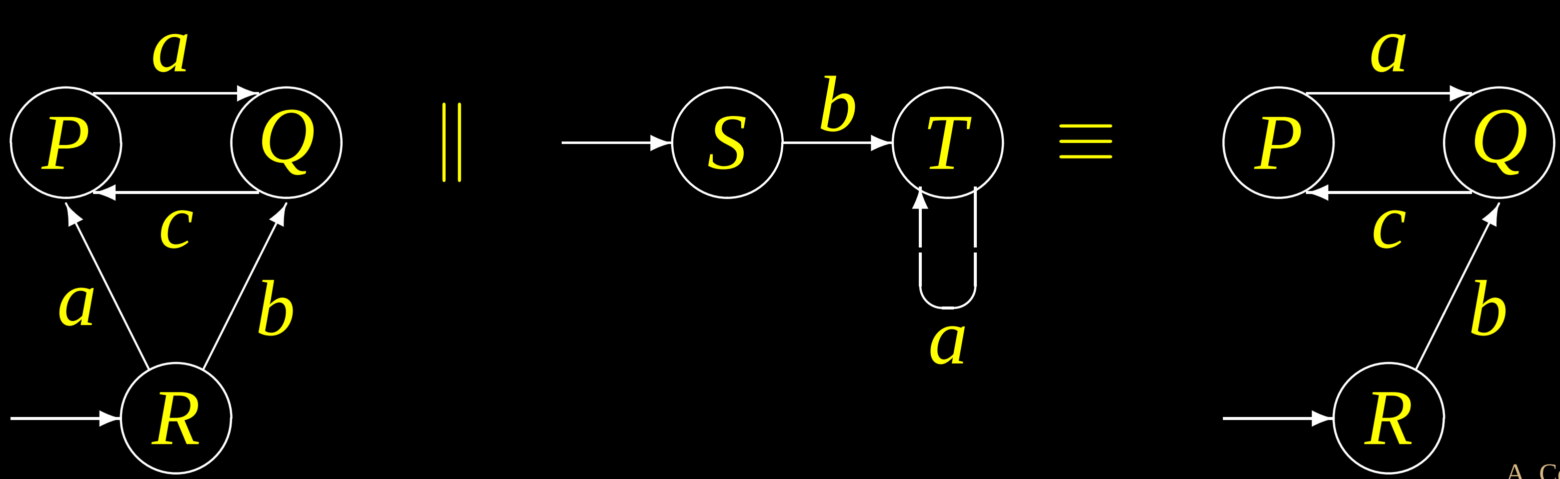

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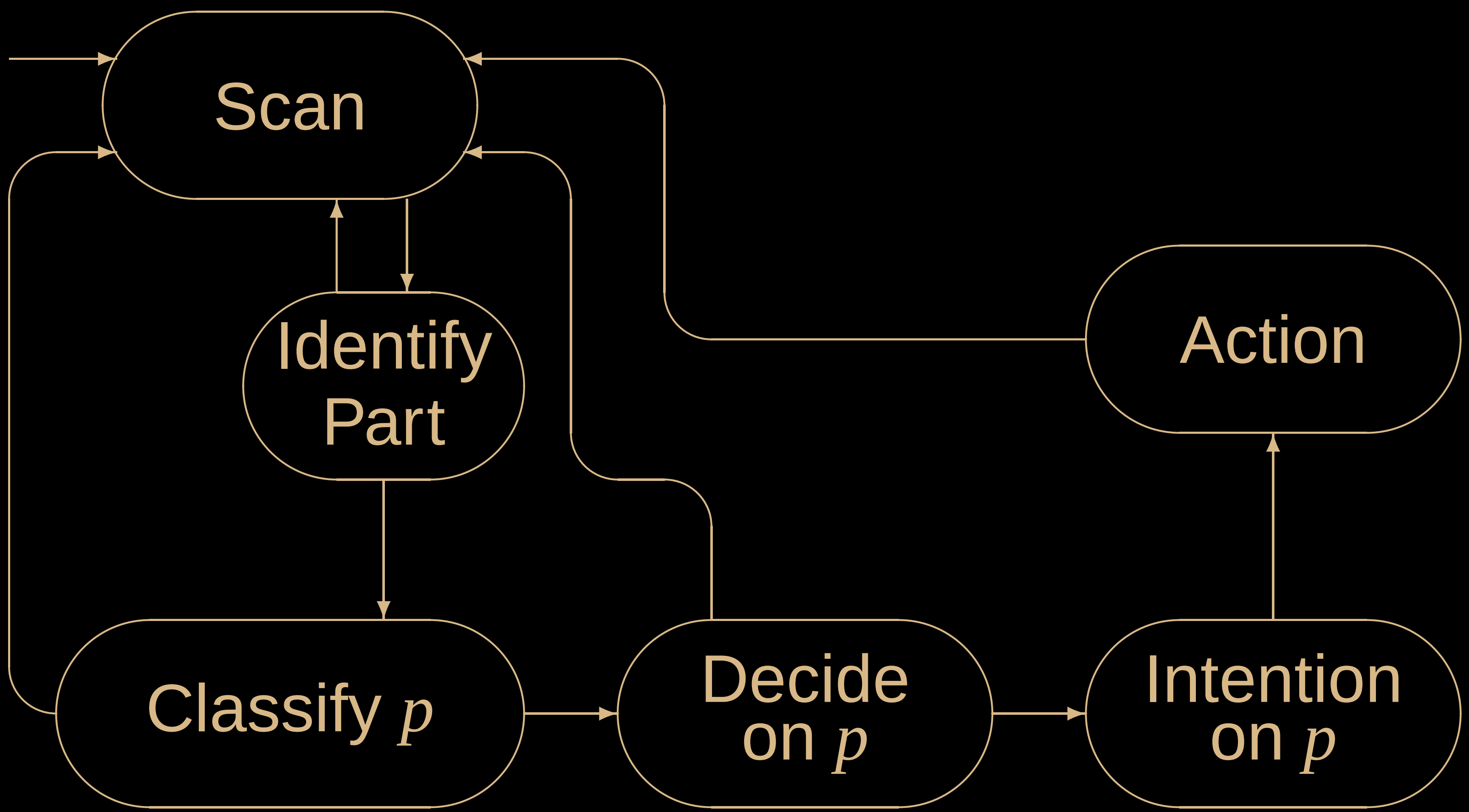
$Assumptions \parallel User \parallel System$
where $System = System_1 \parallel \ldots \parallel System_n$

$User \parallel System$
$User \parallel Environment$
with possibly $User = User_1 \parallel \ldots \parallel User_m$

# *Formal Model using CSP*



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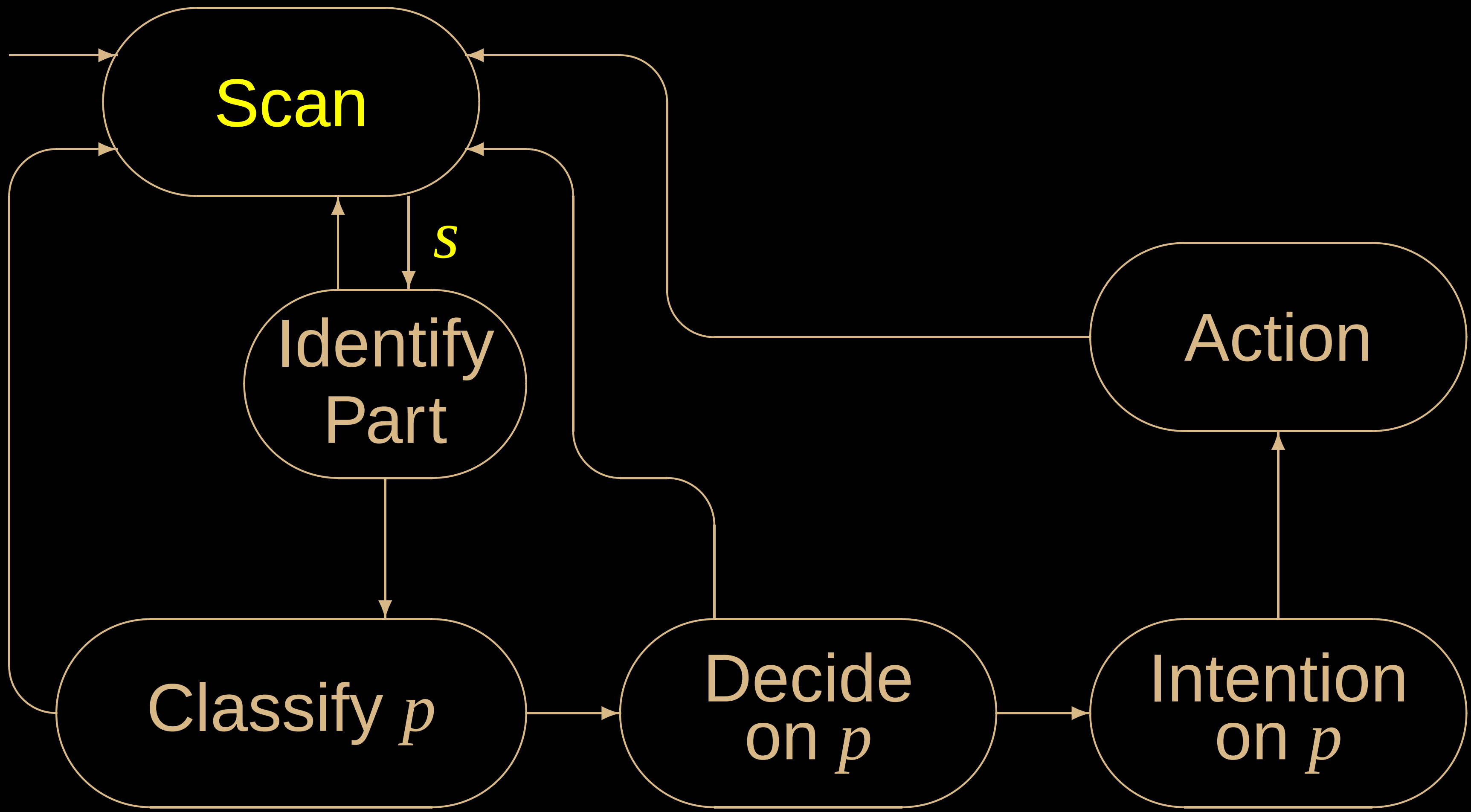
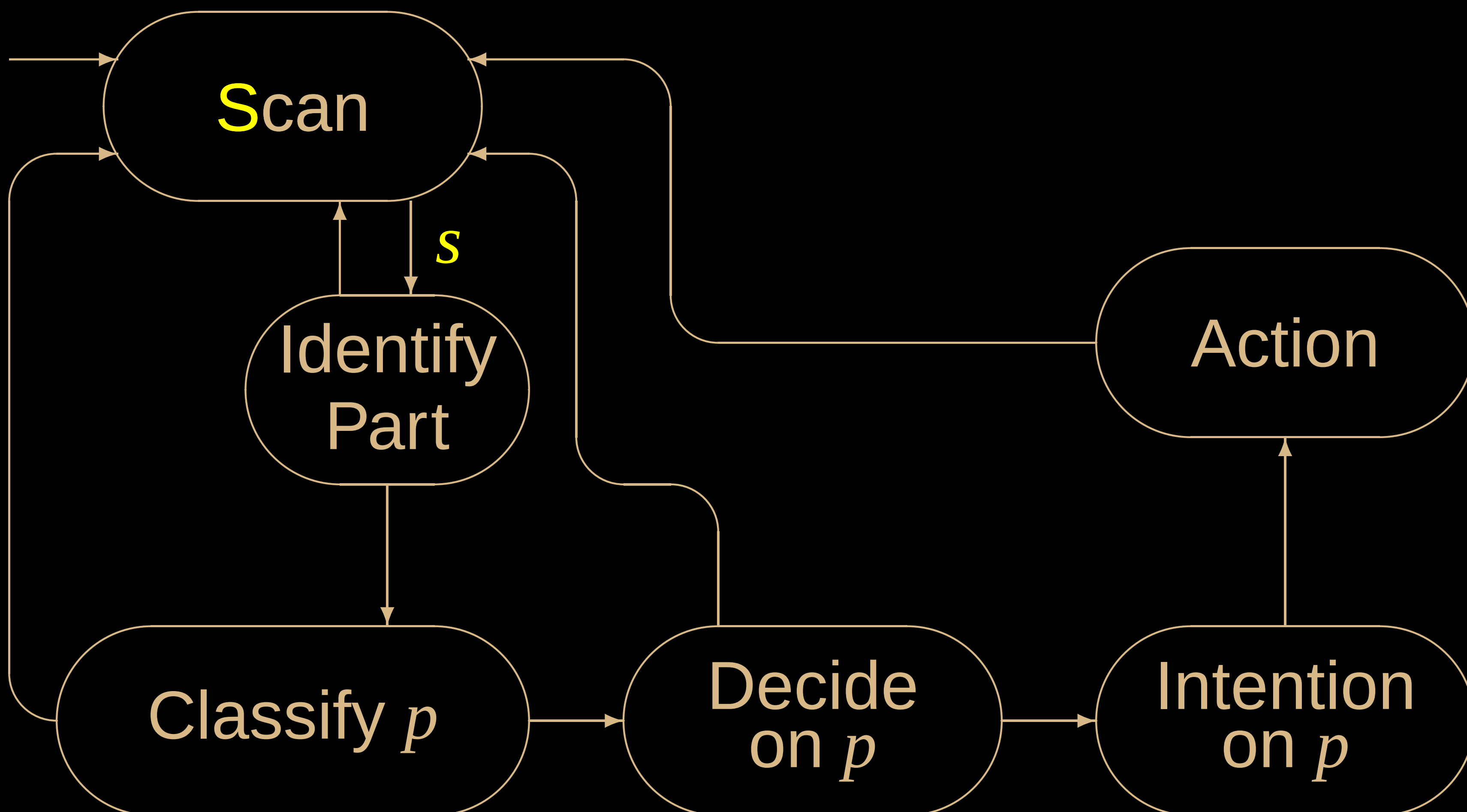


# *Formal Model using CSP*

$$S = s \rightarrow ((\Box_{p:Part} \cdots) \Box S)$$



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Identification: The operator identifies part of the interface that may represent the property

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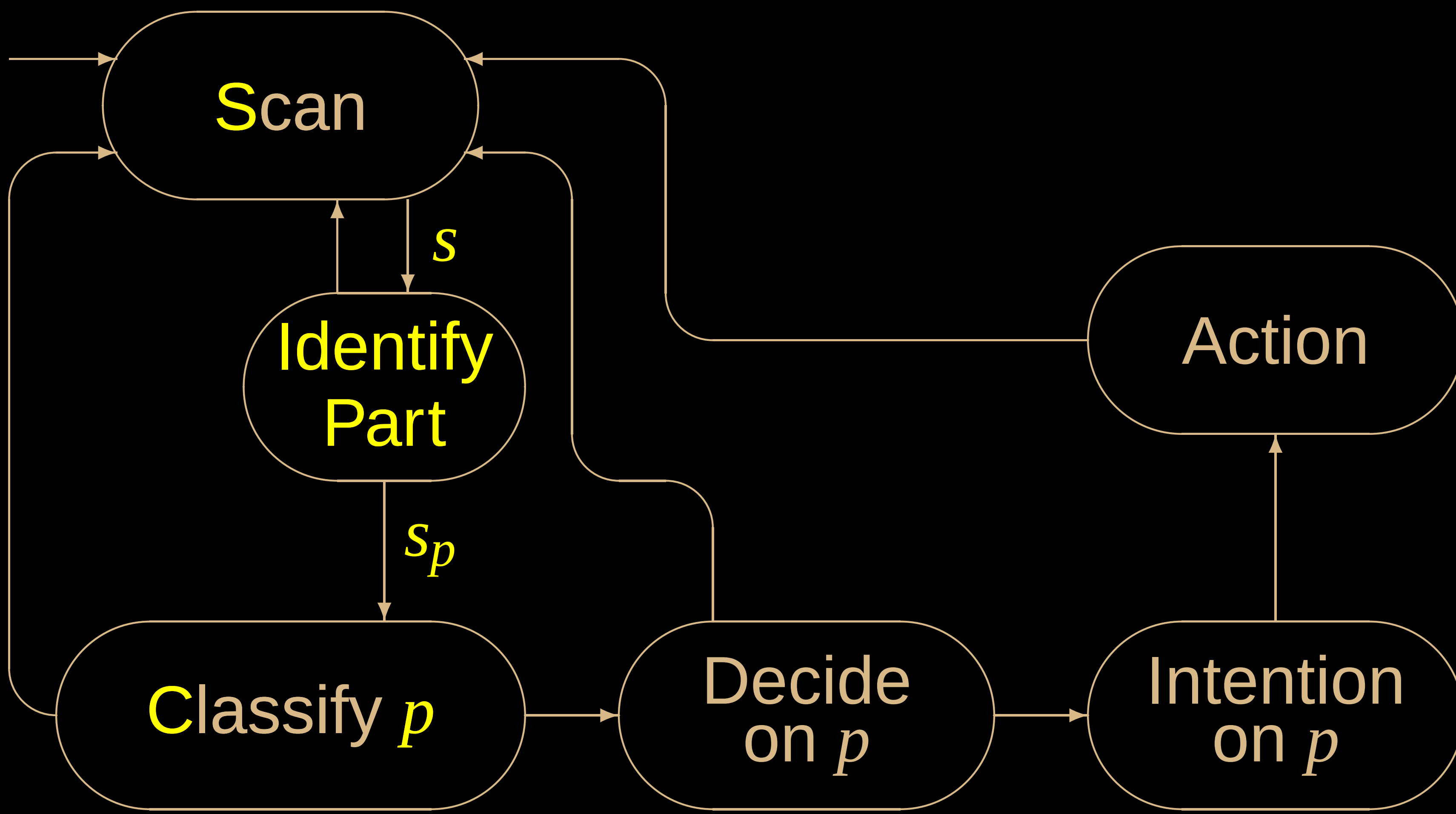

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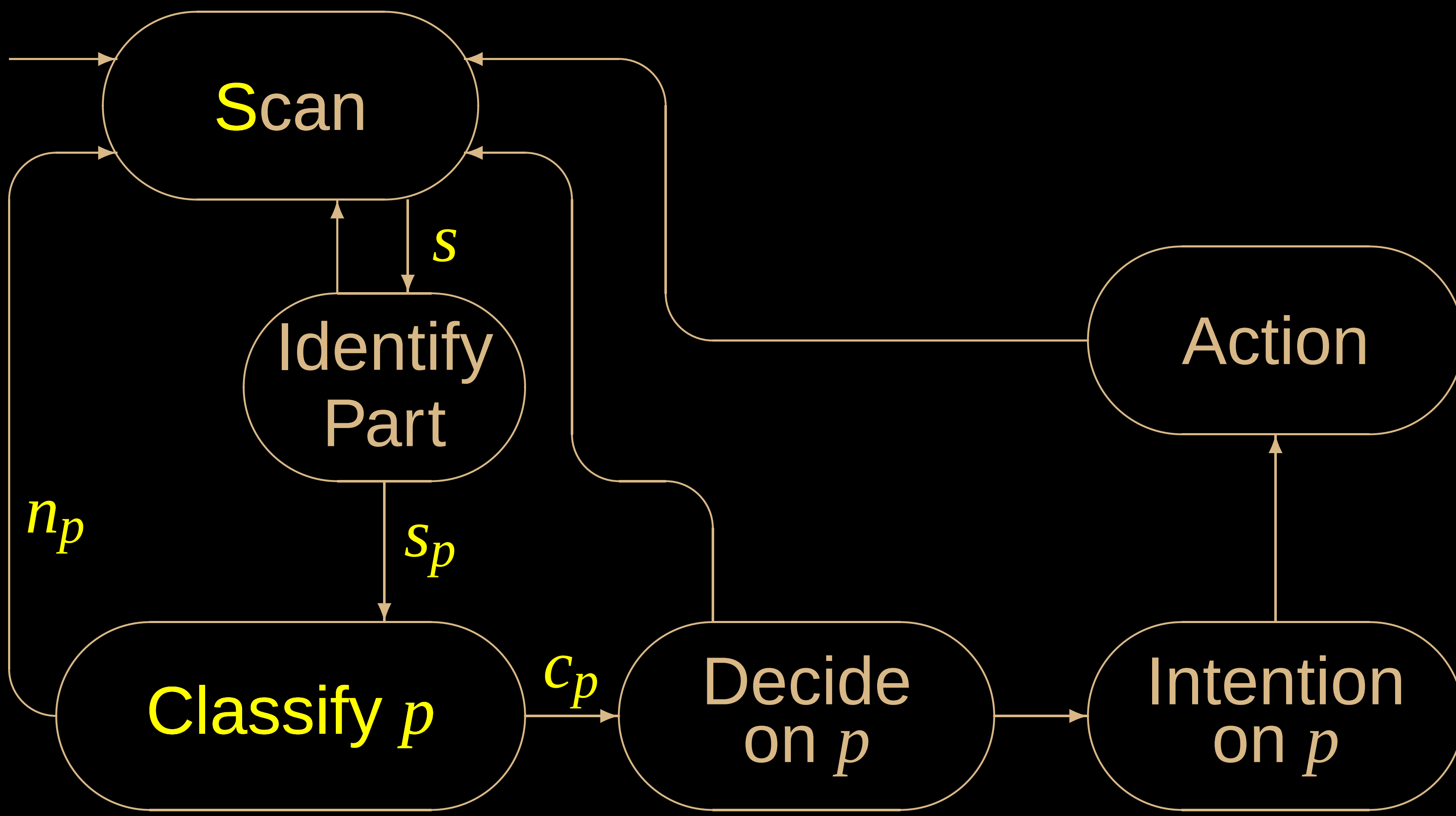

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Classification: If so, the operator gives some form of priority to the property

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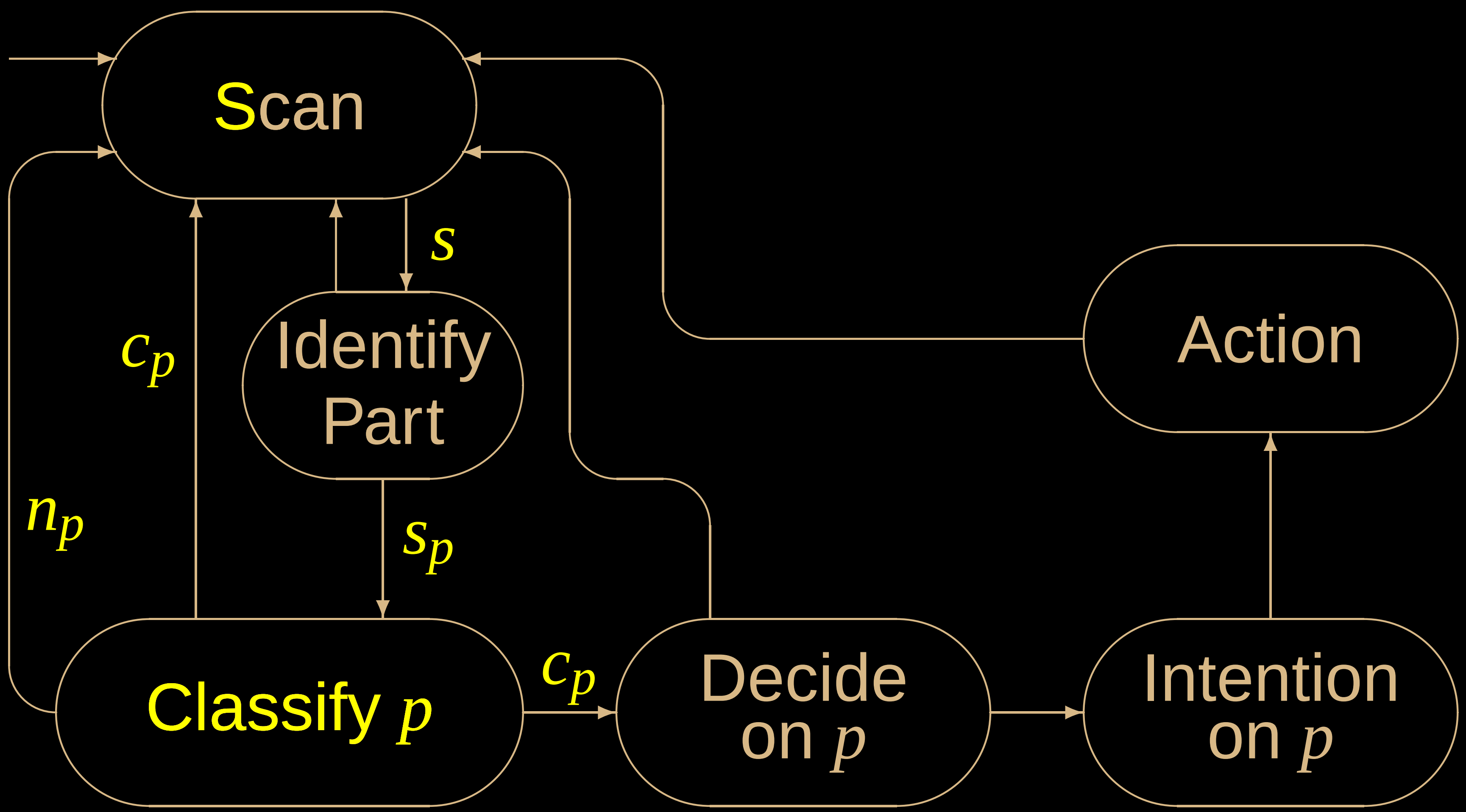

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$$S = s \rightarrow ((\Box_{p:Part}(s_p \rightarrow C_p)) \Box S)$$

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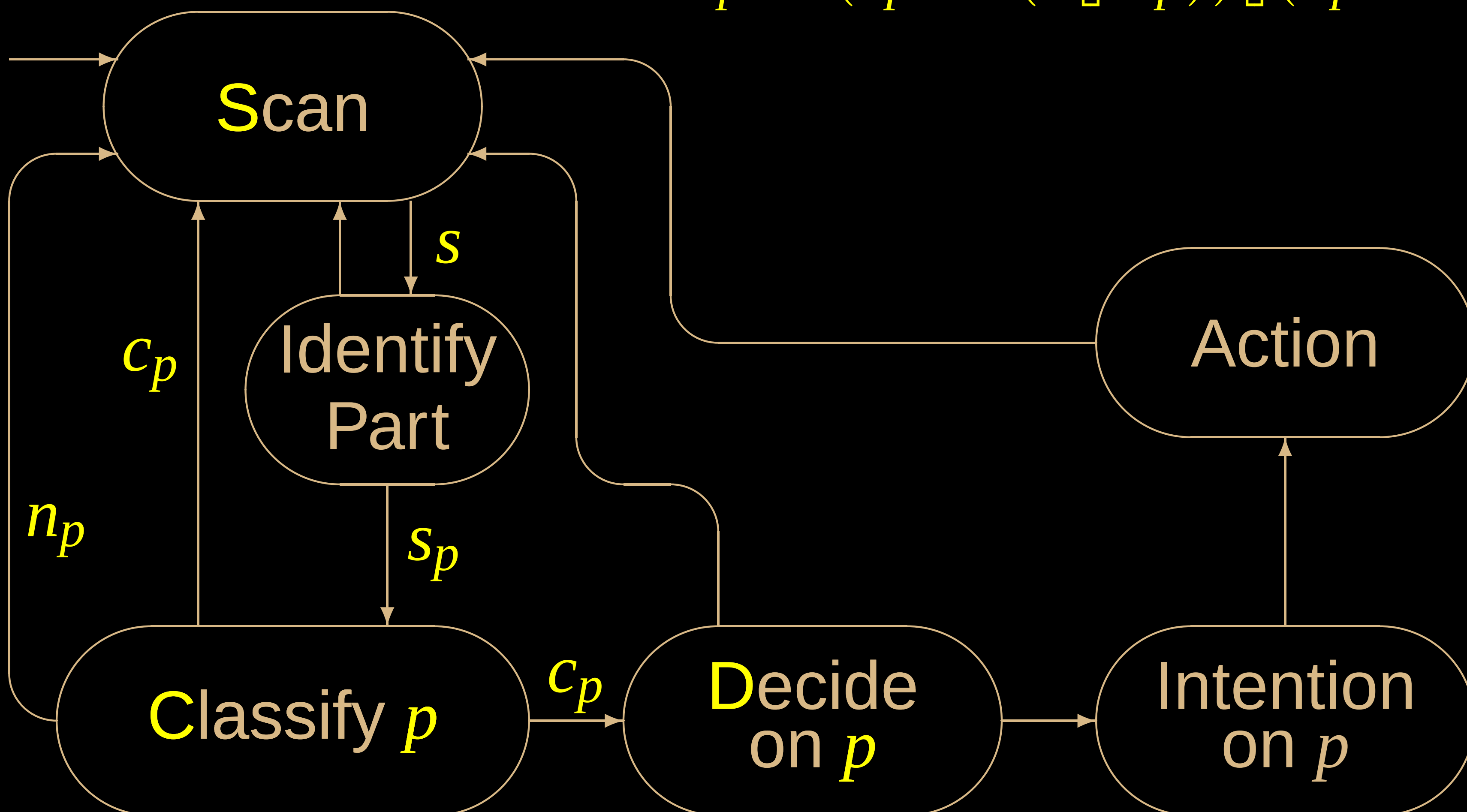

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Decision on how to resolve the situation

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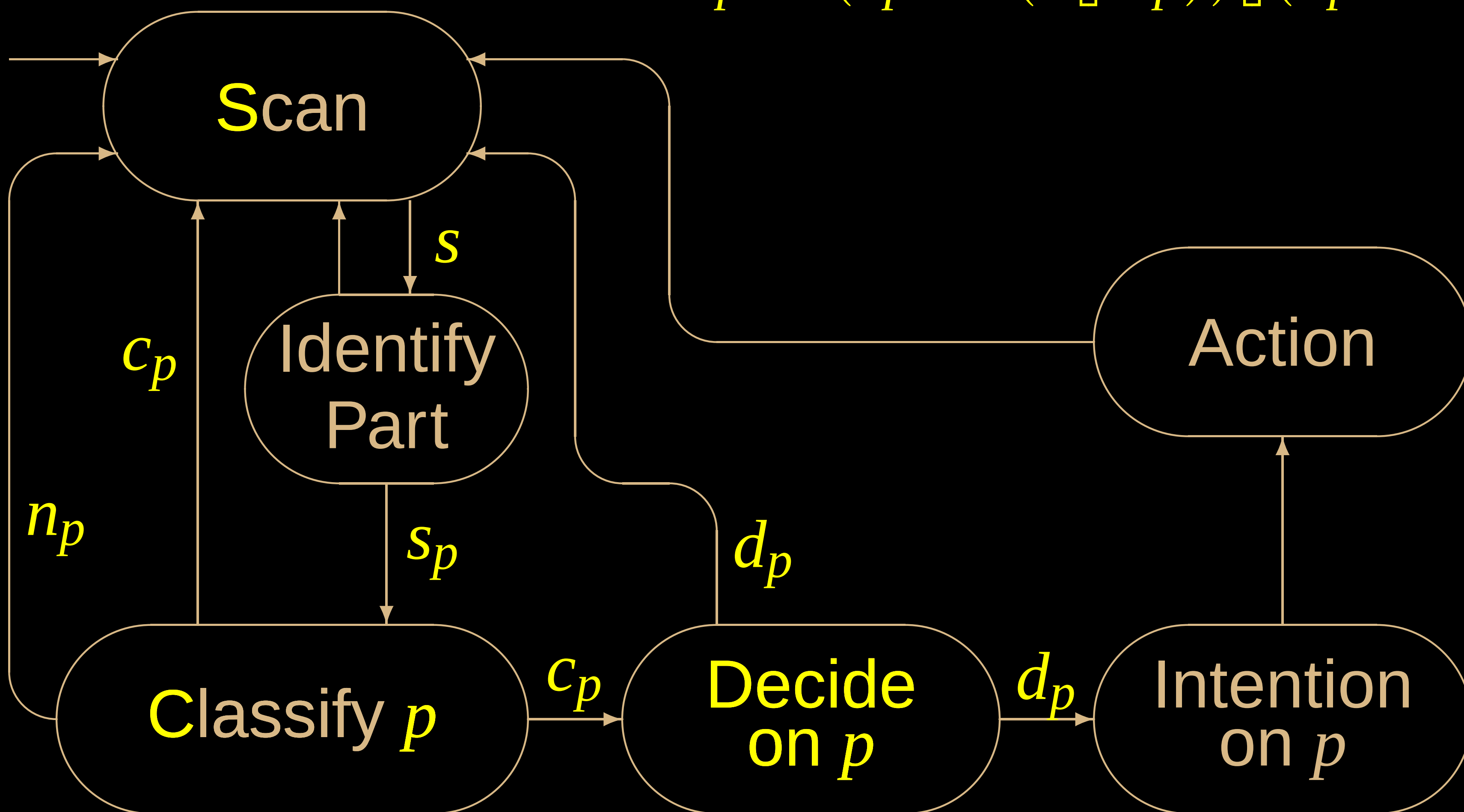

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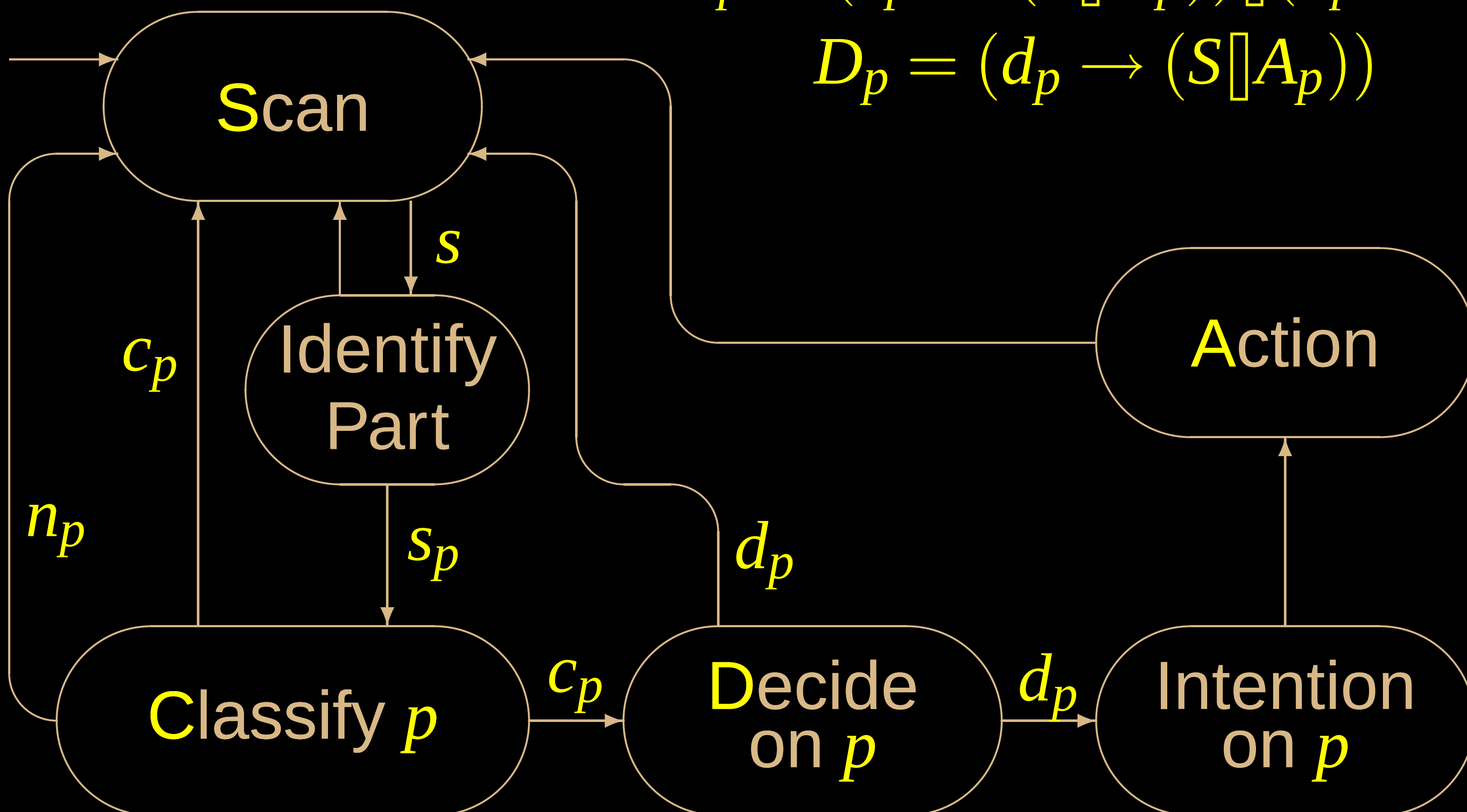

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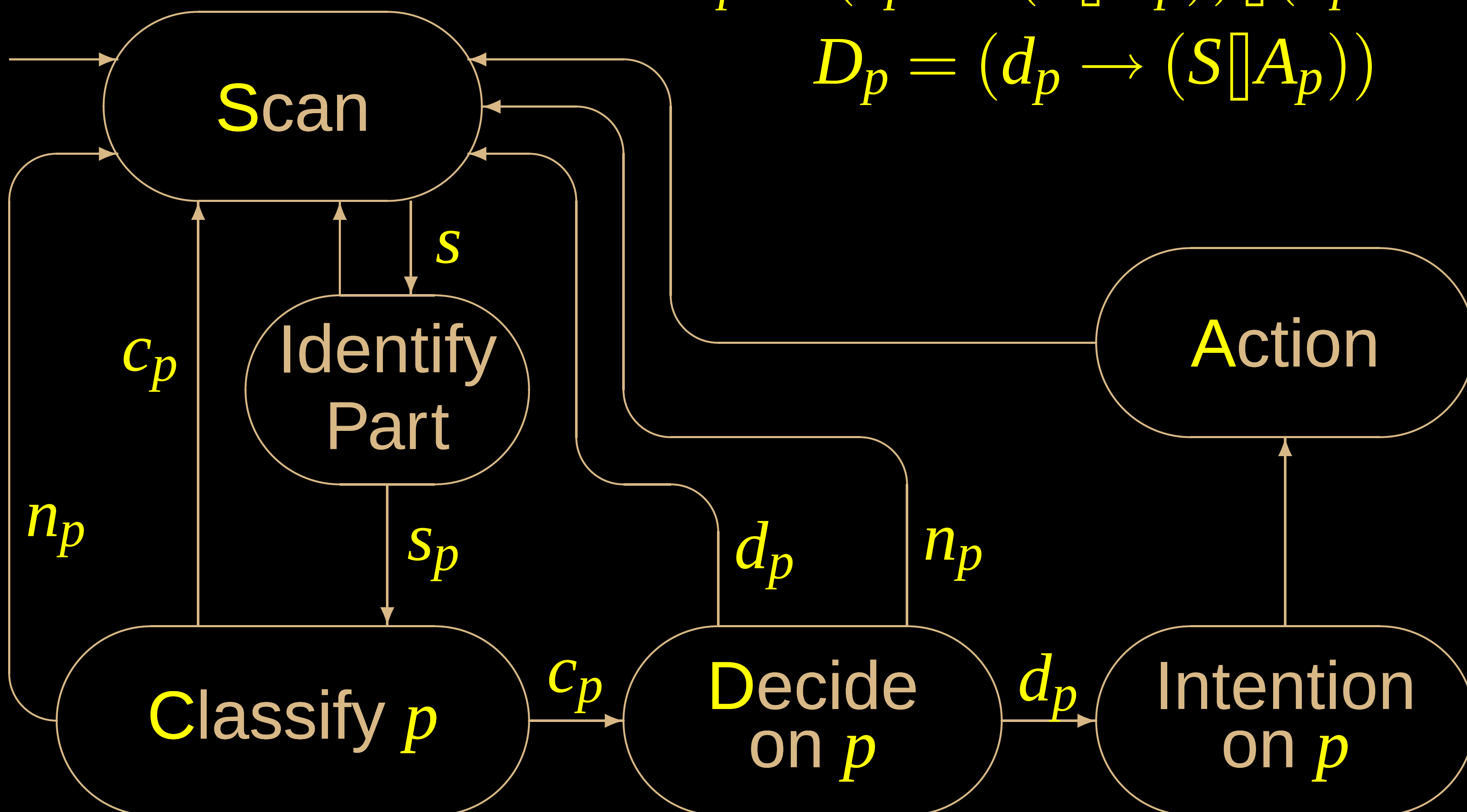

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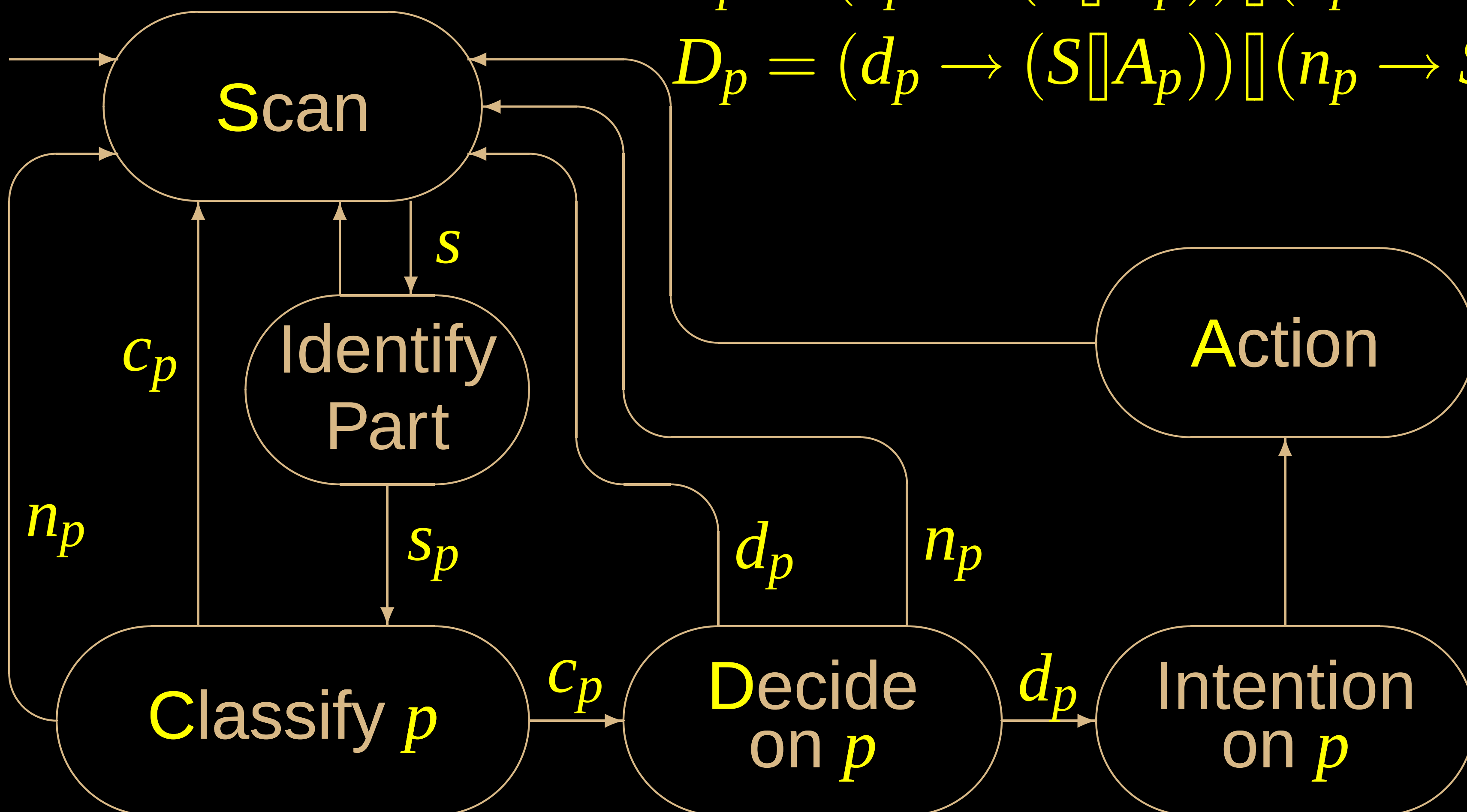

# *Formal Model using CSP*

Action to be performed as a series of interactions with the interface

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