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Designing Vultron

A Protocol for Multi-Party Coordinated Vulnerability Disclosure

Allen Householder

CERT/CC

Software Engineering Institute
Carnegie Mellon University
Pittsburgh, PA 15213

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DM22-0516

Interoperability

Brownsword, Lisa L., et al. *Current perspectives on interoperability*. Tech. Rep. CMU/SEI-2004-TR-009, Software Engineering Institute, Carnegie-Mellon University, Pittsburgh, PA, 2004.

More than just data exchange!

The ability of a **collection** of **communicating entities** to

- **share** specified **information** and
- **operate** on that information **according to** an **agreed** operational **semantics**

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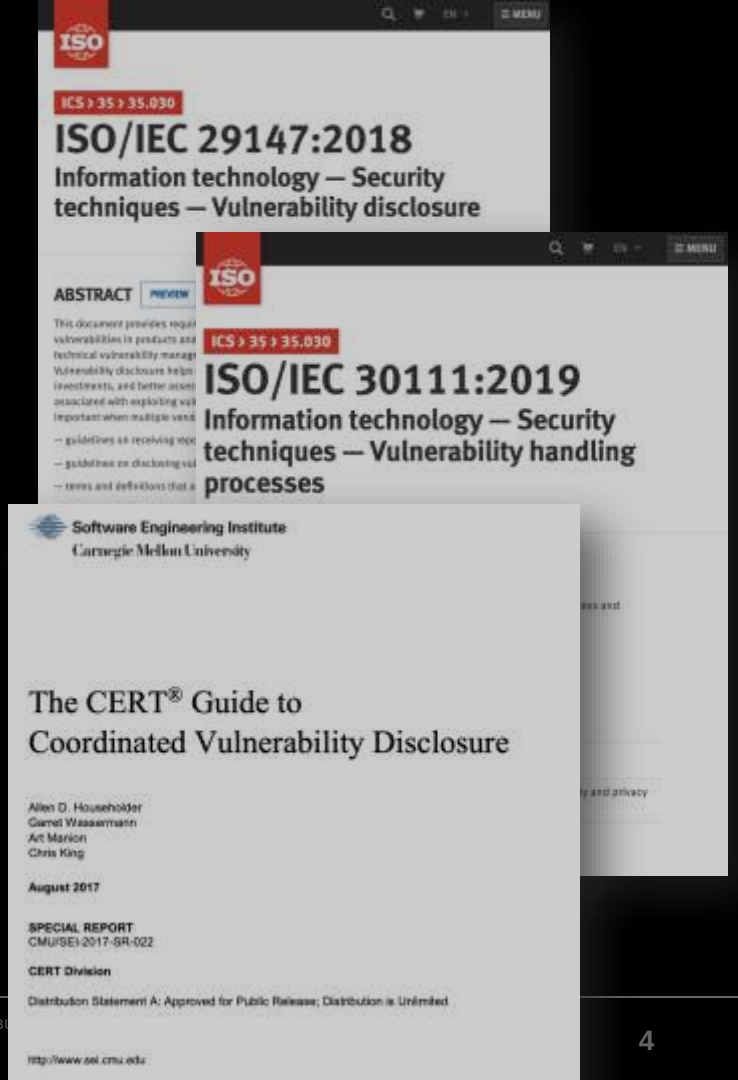
What we mean by ***protocol***

1. Accepted **code of behavior** of a group or organization
   - ISO/IEC 29147, ISO/IEC 30111
   - CERT Guide to CVD, extended in this work

2. Set of **rules** governing the **exchange of data** via a communications channel
   - Starts in this work, more to do in the future



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MPCVD Protocol

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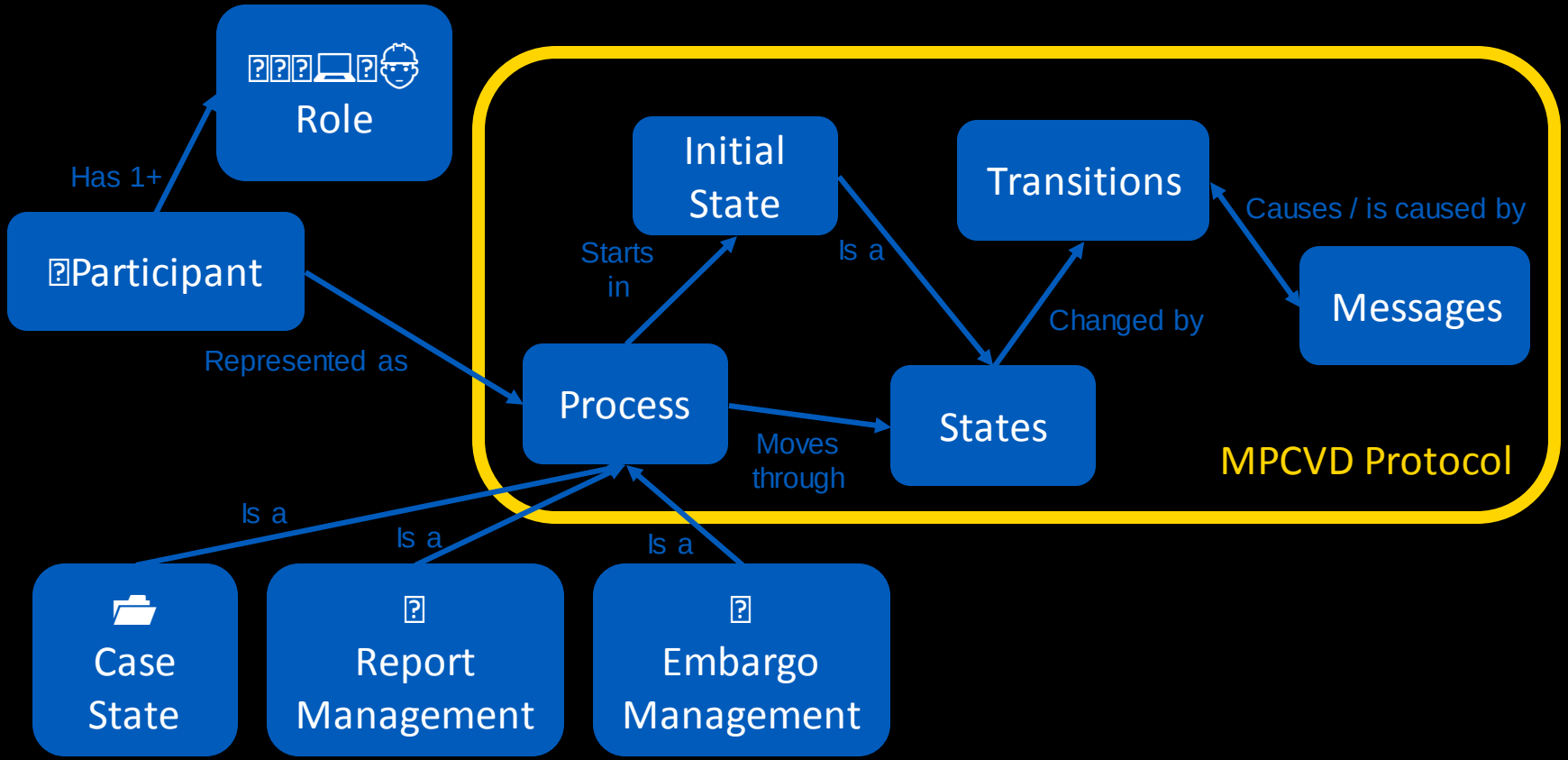

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CVD is comprised of **Participants** in **Roles** doing **Processes**

CVD Roles

- Finder/Reporter
- Vendor
-
- Coordinator
-
  Deployer

CVD Processes

-
  Case State
- Report Mgt
- Embargo Mgt

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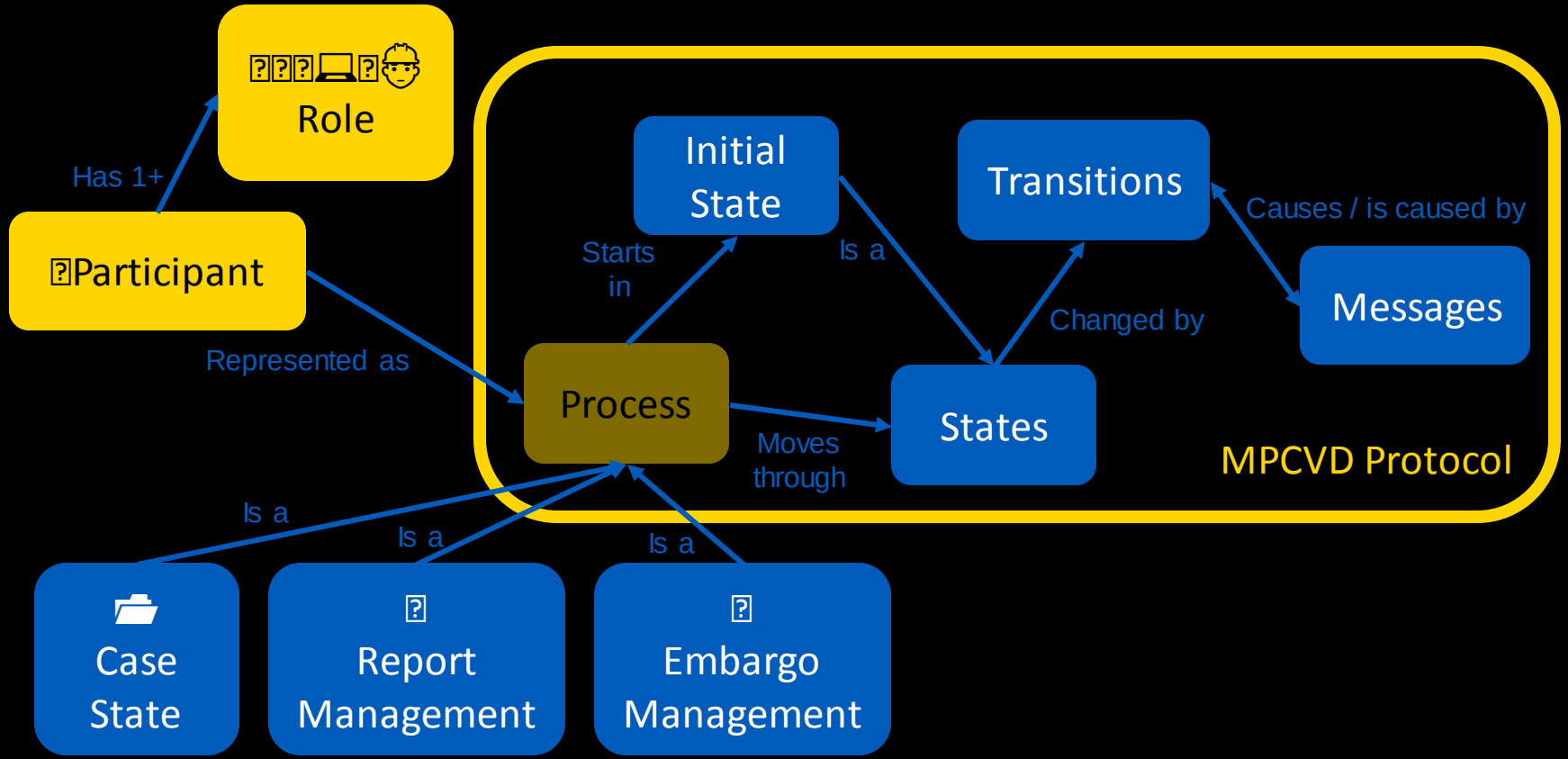

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Case State Model

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Case State Model

Householder, A. D., and Jonathan Spring. *A State-Based Model for Multi-Party Coordinated Vulnerability Disclosure (MPCVD)*. Tech. Rep. CMU/SEI-2021-SR-021, Software Engineering Institute, Carnegie-Mellon University, Pittsburgh, PA, 2021.

F = Fix Ready

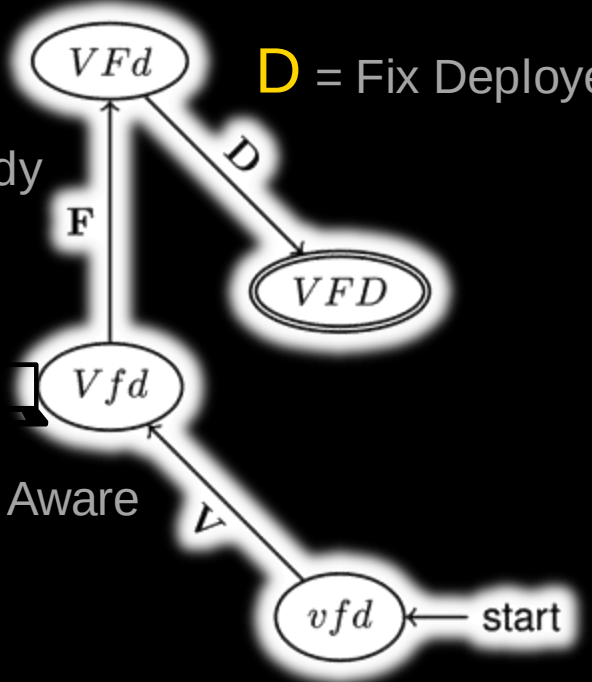
D = Fix Deployed

V = Vendor Aware

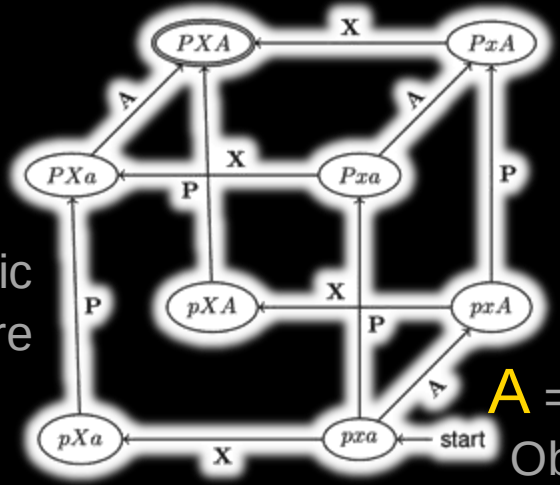
X = Exploit Public

P = Public Aware

A = Attacks Observed



Vendor Unaware



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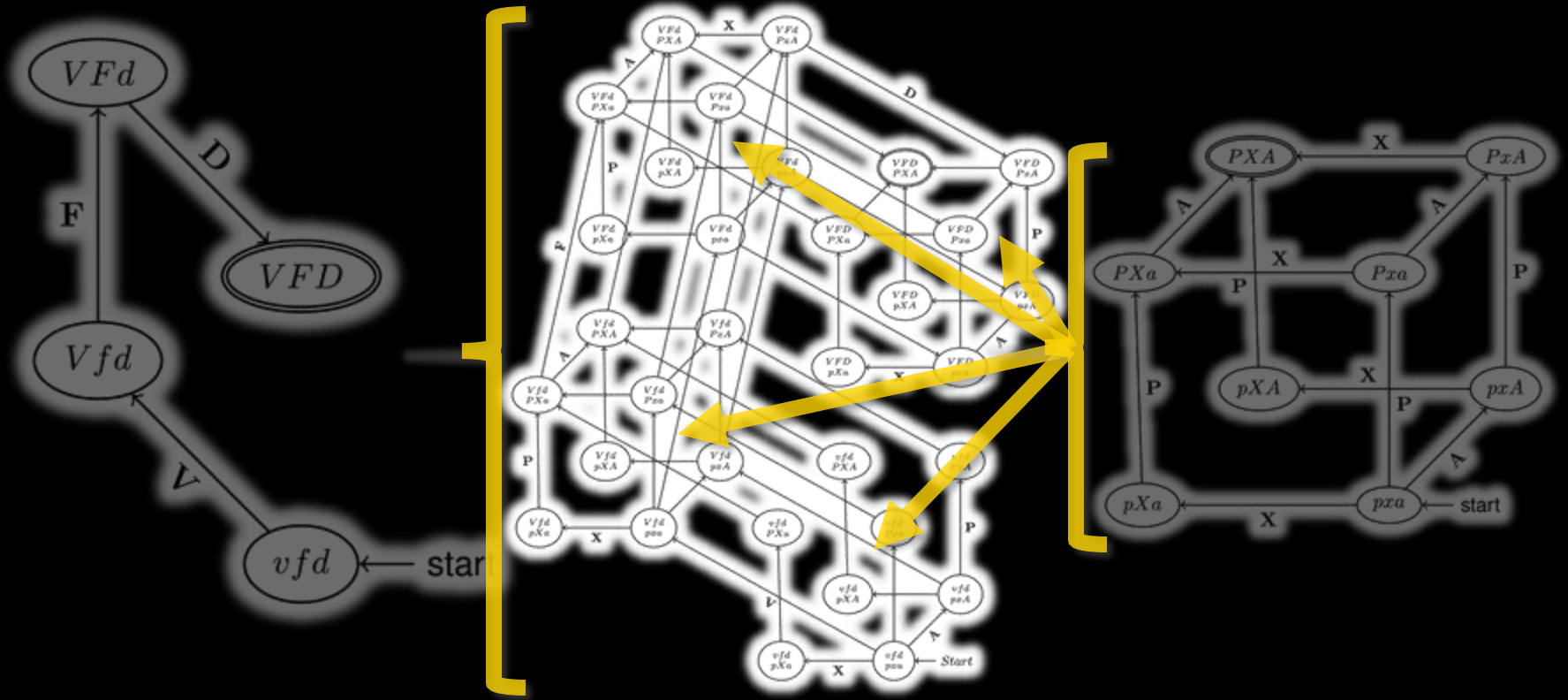

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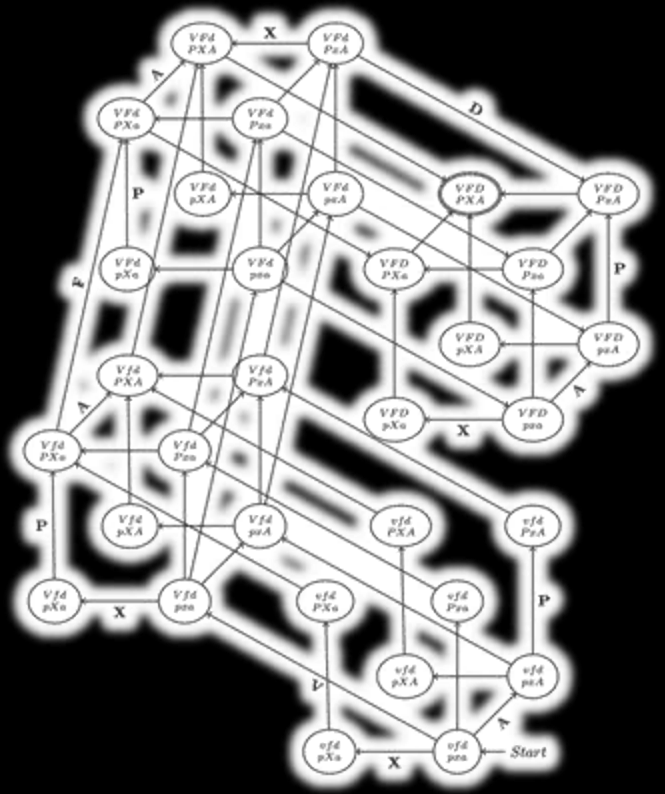

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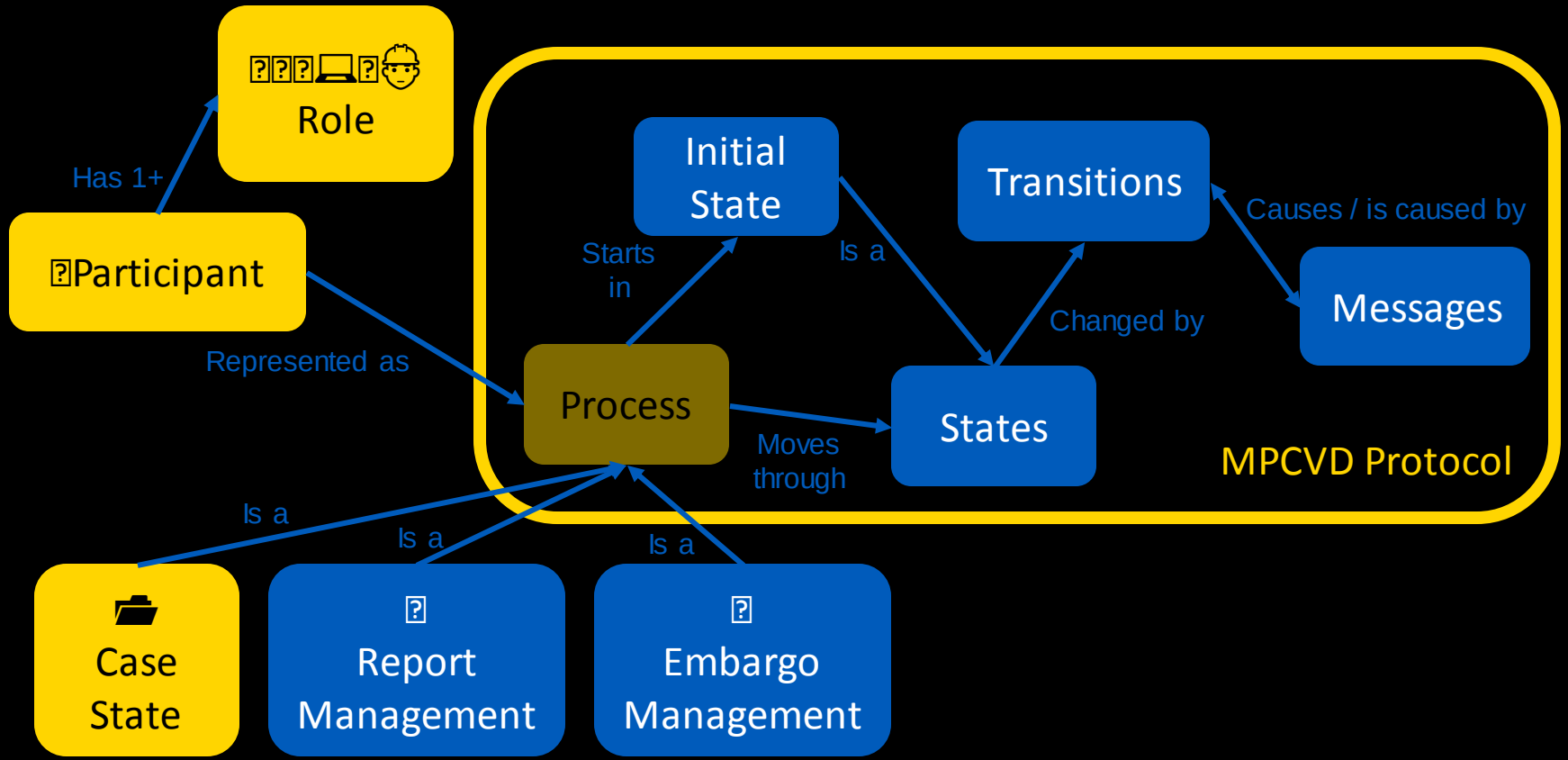

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Report Management

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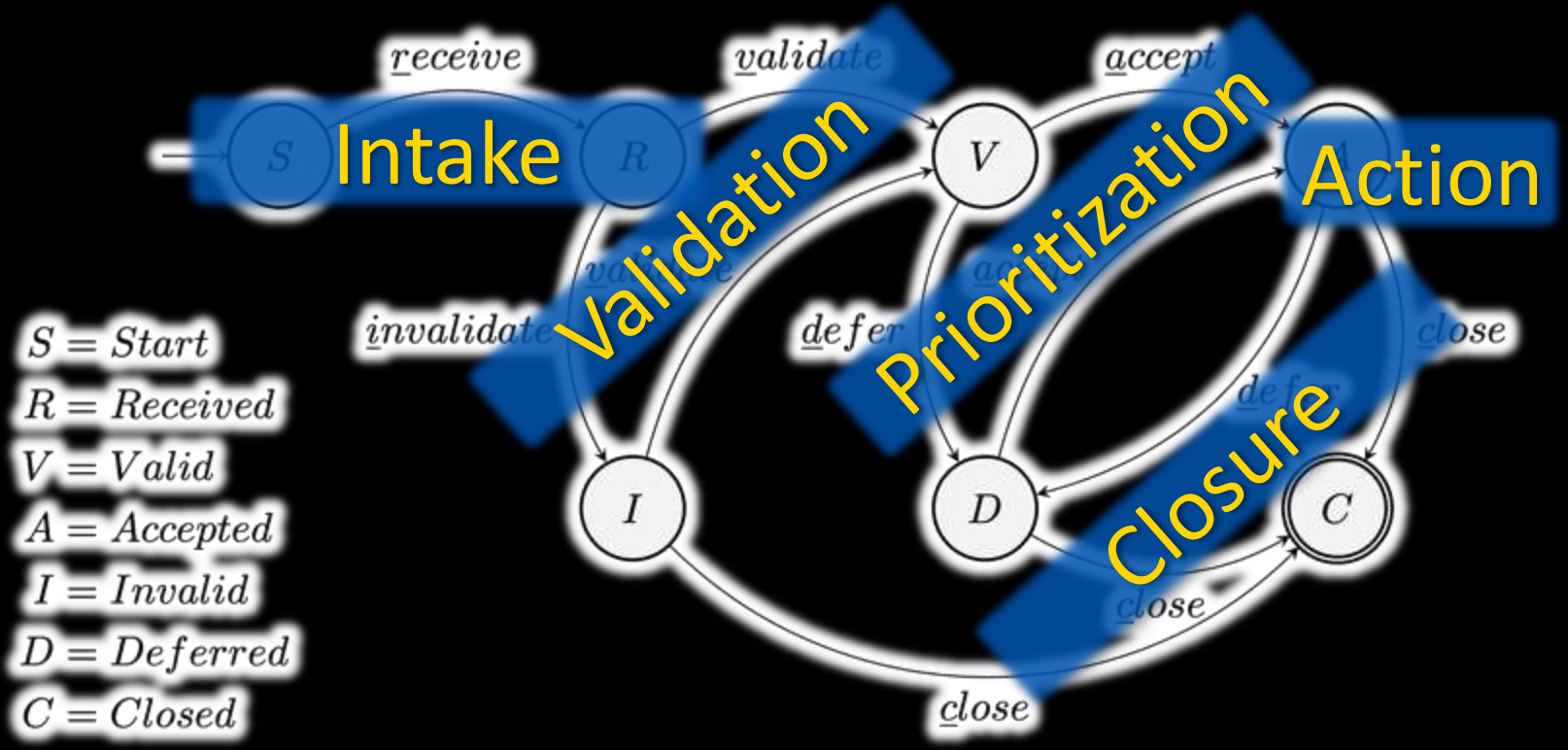
Report Management



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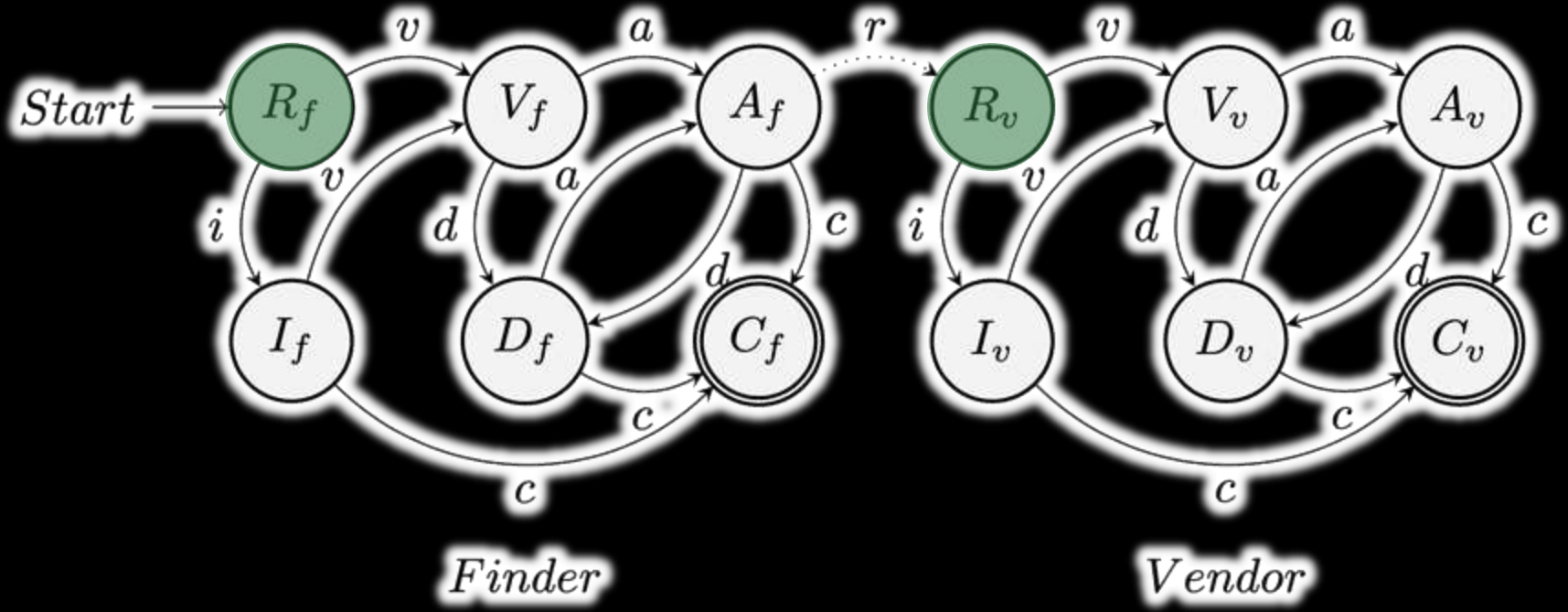
Basic CVD



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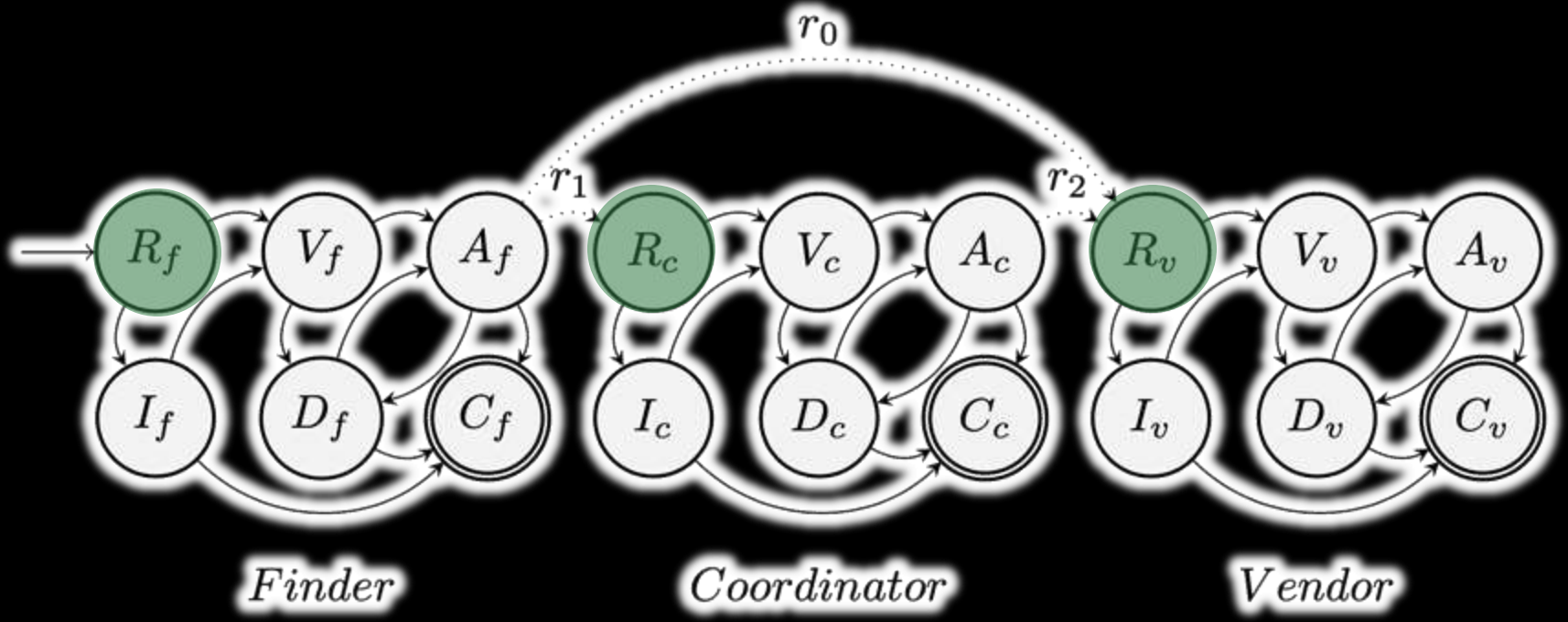
Basic CVD + Coordinator



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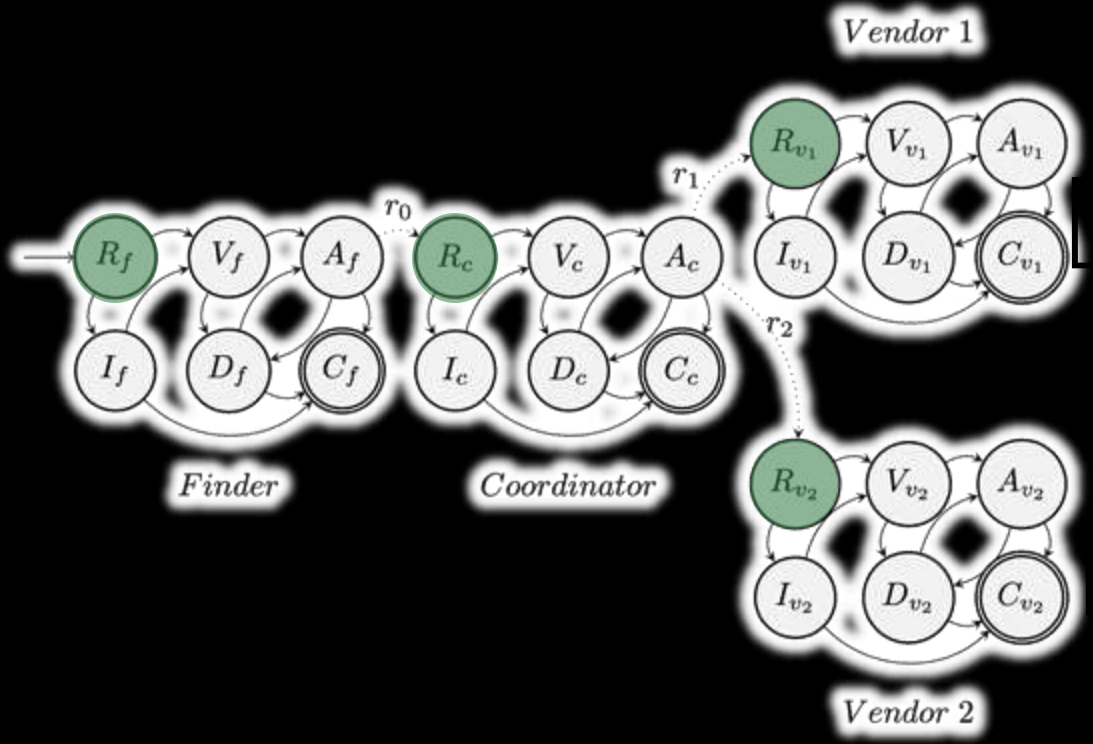
Basic MPCVD + Coordinator



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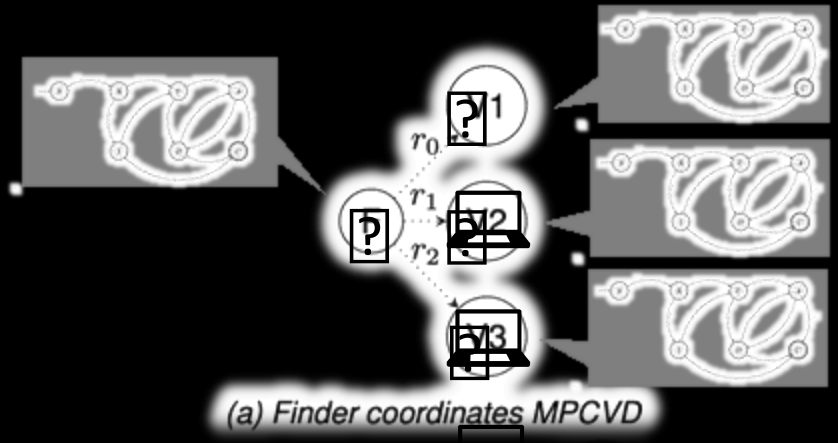
Other MPCVD Scenarios



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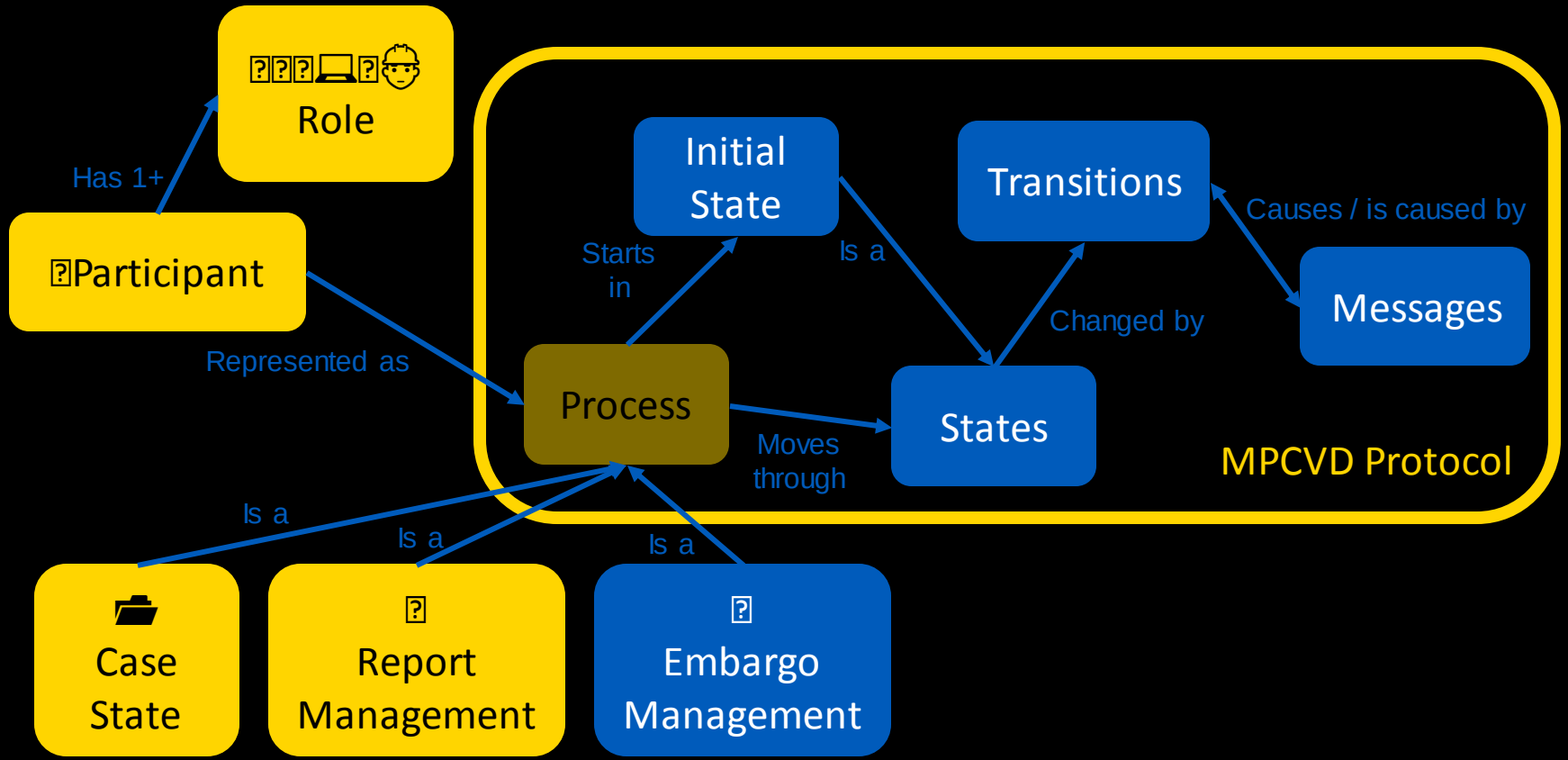

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Embargo Management

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Embargo Management

Pre-Embargo

Active Embargo

Post-Embargo

$N = \underline{N}one$

$P = None + \underline{P}roposed$

$A = \underline{A}ctive$

$R = Active + \underline{R}evise$

$X = e\underline{X}ited$

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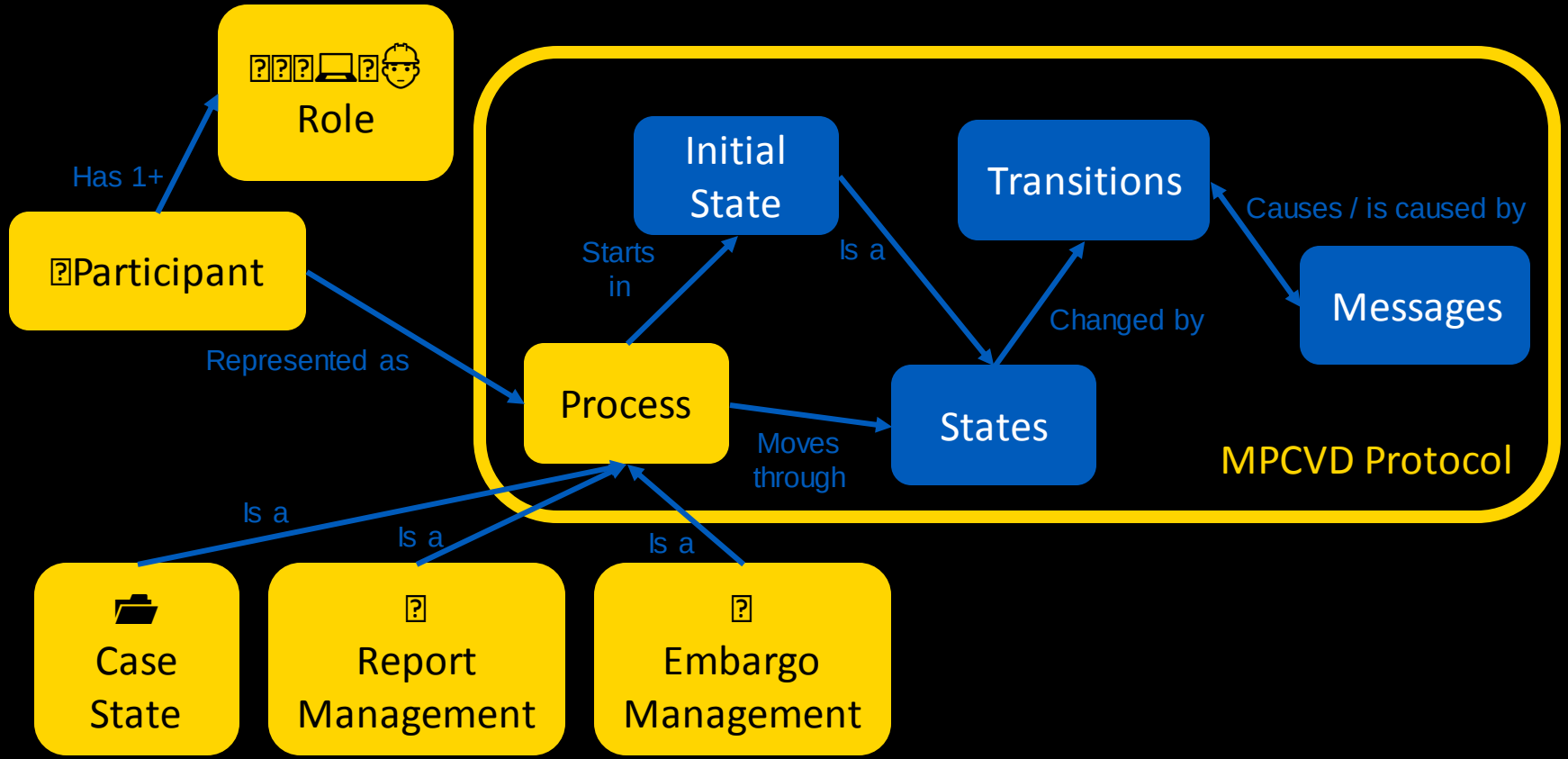

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Participant States

$$S_i = \underbrace{\begin{bmatrix} S \\ R \\ I \\ V \\ D \\ A \\ C \end{bmatrix}}_{\mathcal{Q}^{rm}} \times \underbrace{\begin{bmatrix} N \\ P \\ A \\ R \\ X \end{bmatrix}}_{\mathcal{Q}^{em}} \times \underbrace{\left[\begin{bmatrix} \varnothing \\ vfd \\ Vfd \\ VFd \\ VFD \end{bmatrix} \times \begin{bmatrix} p \\ P \end{bmatrix} \times \begin{bmatrix} x \\ X \end{bmatrix} \times \begin{bmatrix} a \\ A \end{bmatrix} \right]}_{\mathcal{Q}^{cs}}$$

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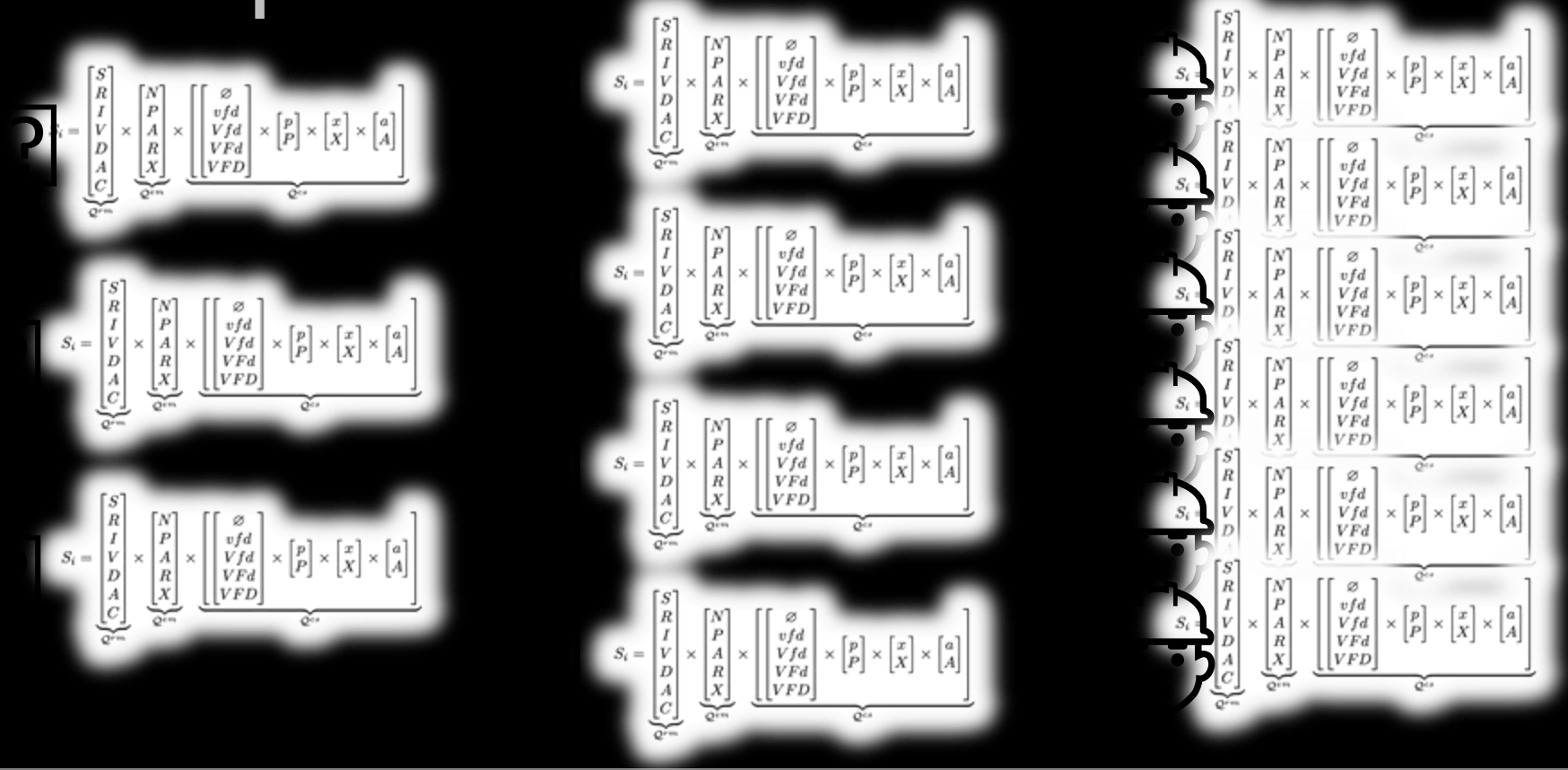
Participant States



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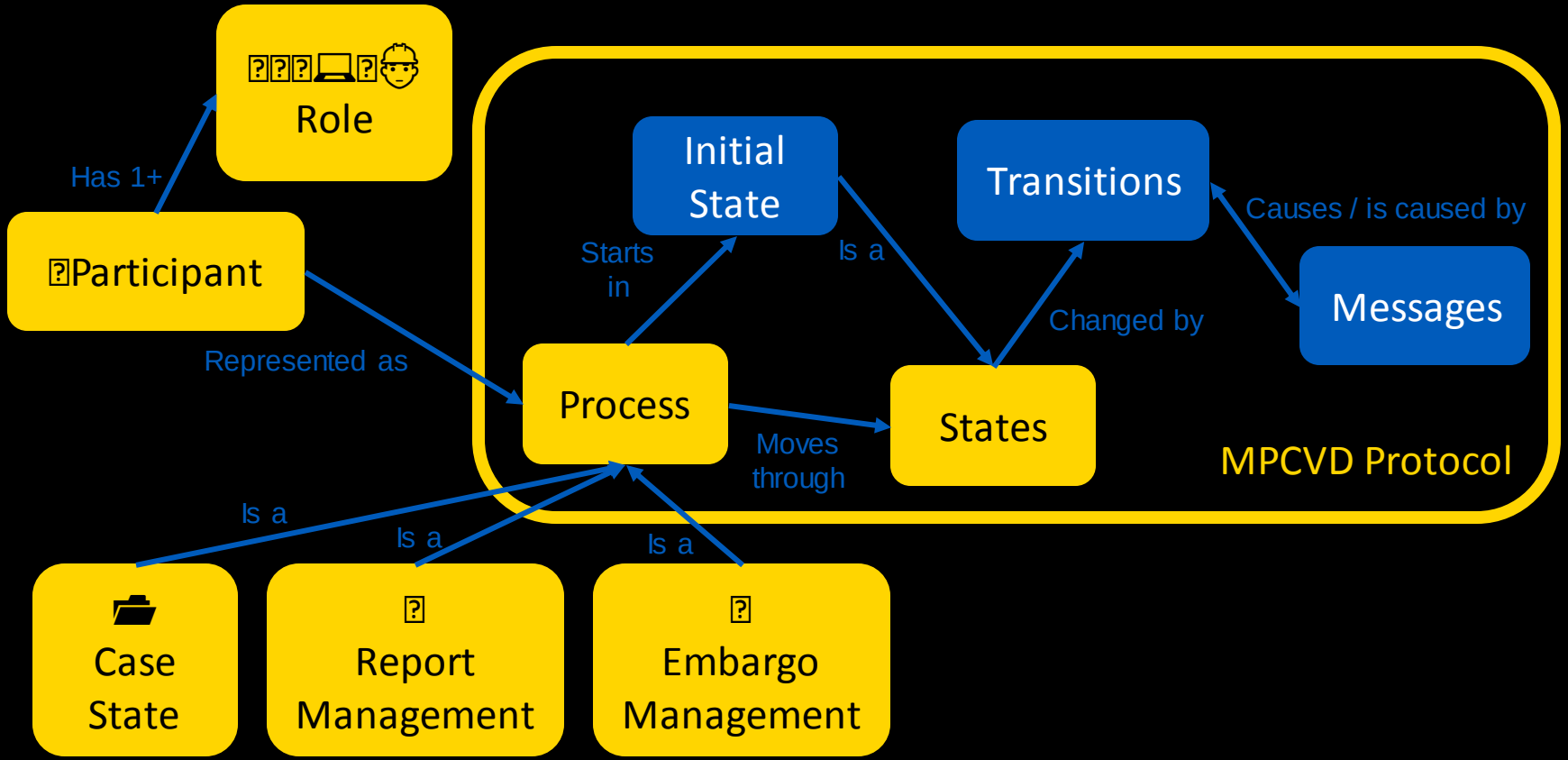

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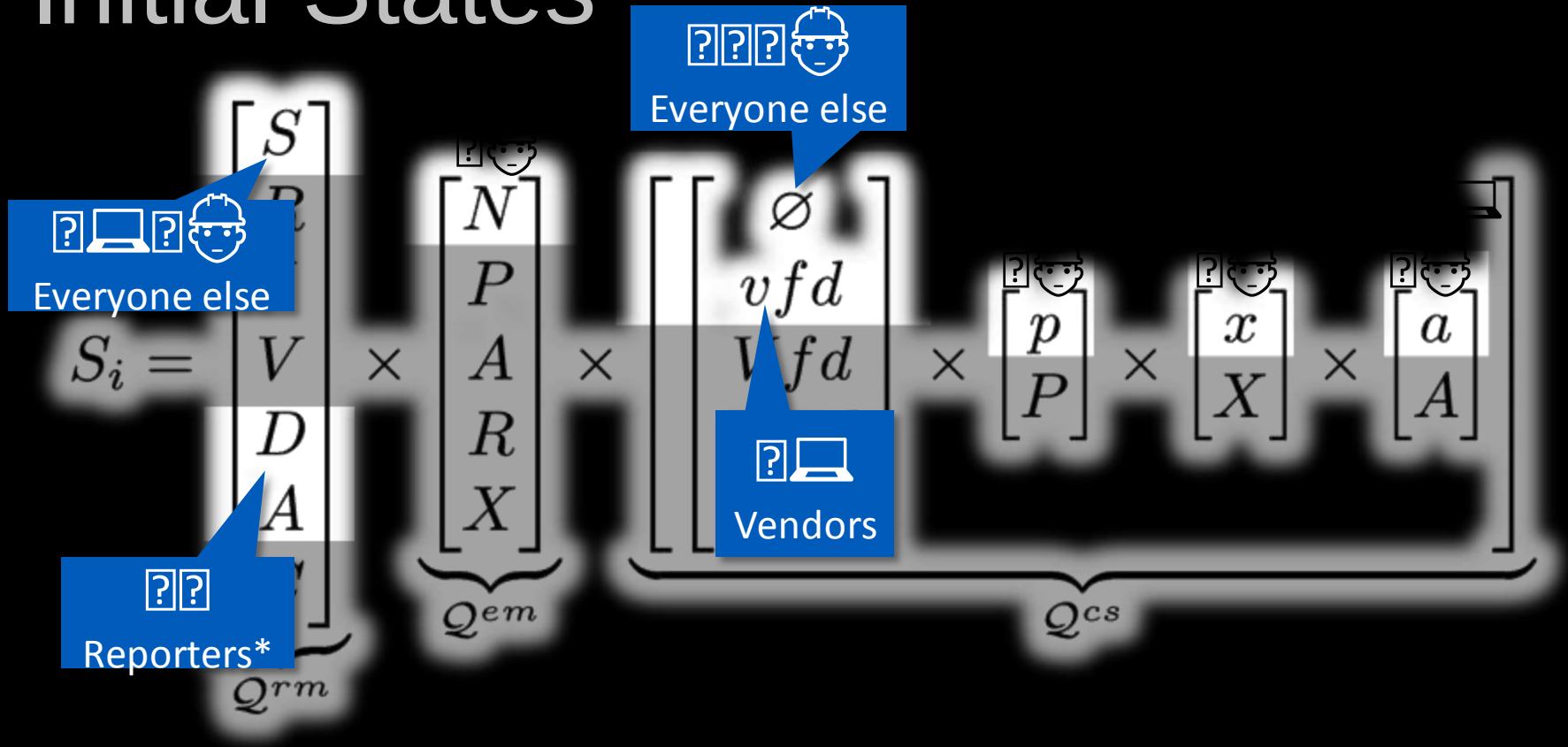
Initial States



*Finder state is hidden until they decide to become reporters

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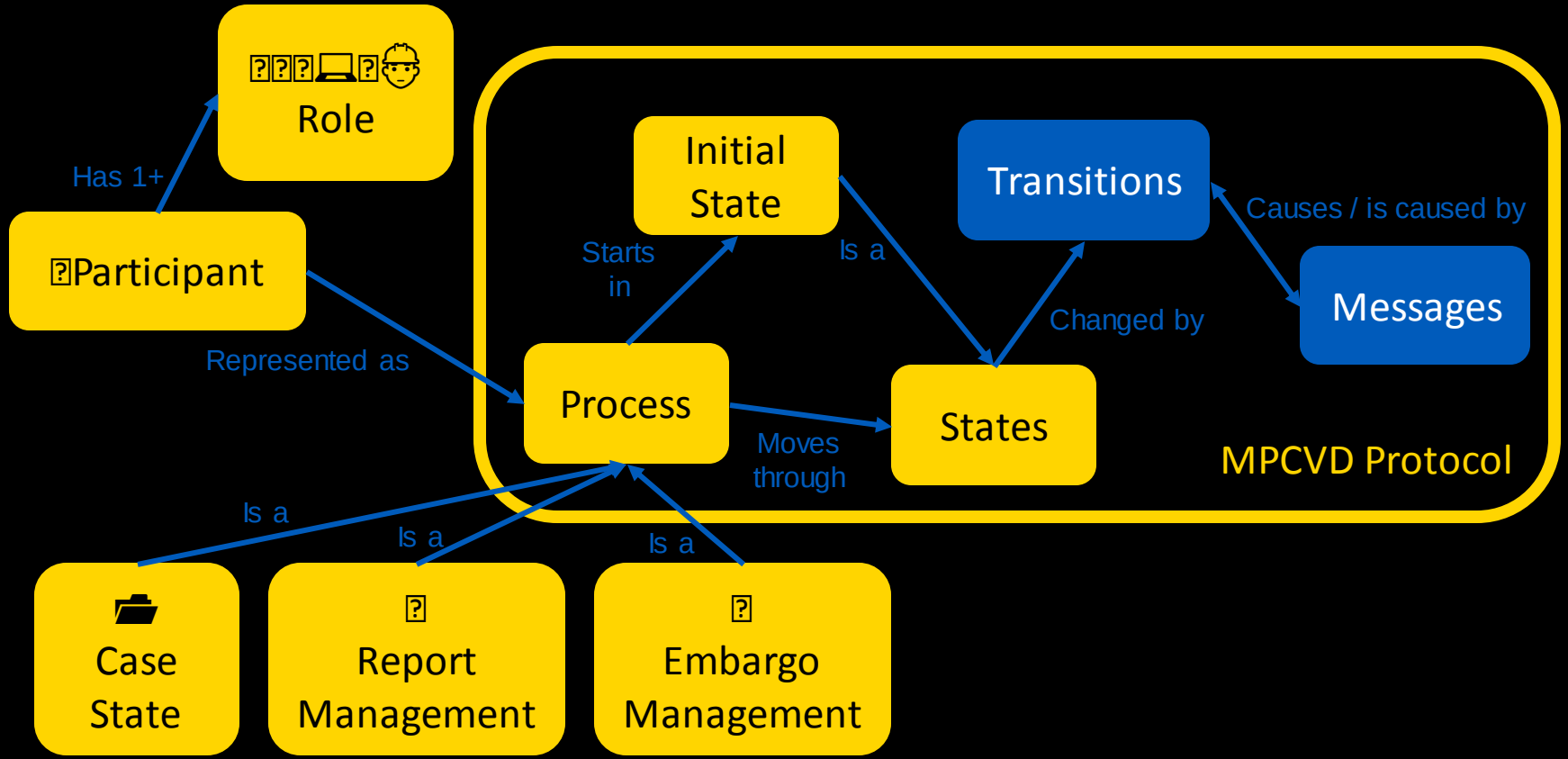

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Message Types

Message Category	State-related	Ack & Errors
Report Management	*RS, RI, RV, RD, RA, RC*	*RK, RE*
Embargo Management	*EP, ER, EA, EV, EJ, EC, ET*	*EK, EE*
Case State	*CV, CF, CD, CP, CX, CA*	*CK, CE*
General	*GI*	*GK, GE*

When a state changes, send a message

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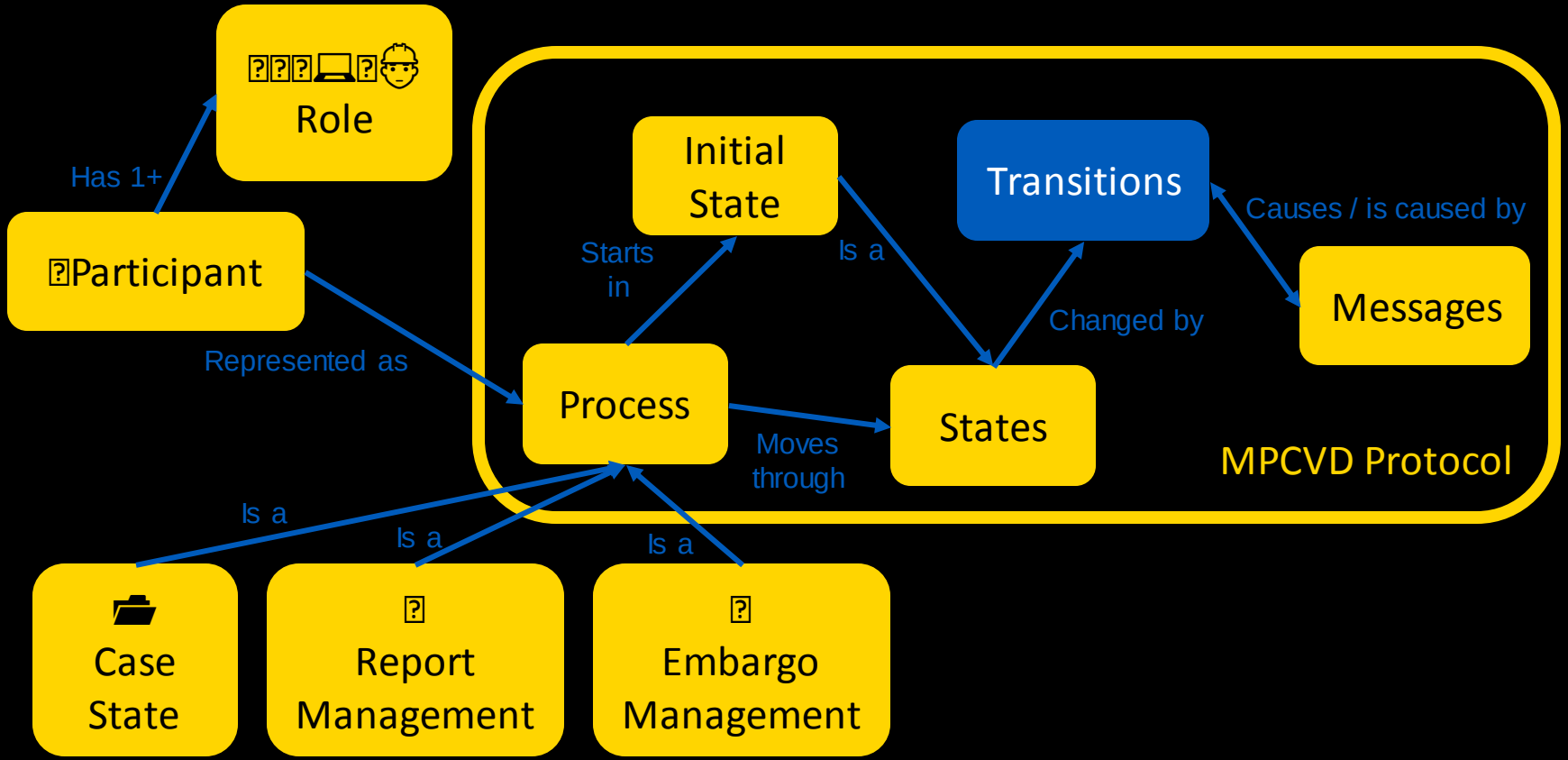

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Designing Vultron

MPCVD Protocol In Motion

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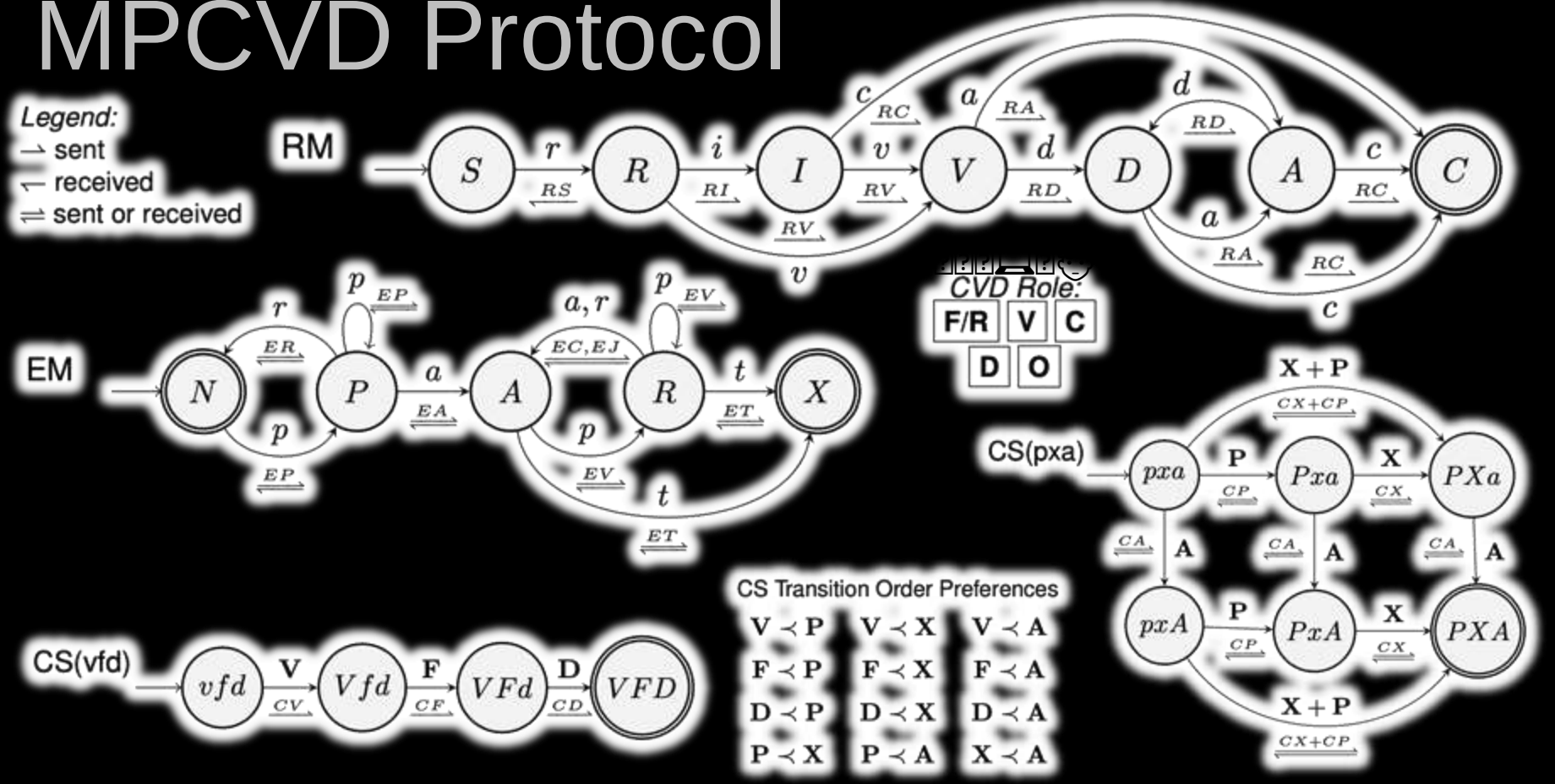
MPCVD Protocol



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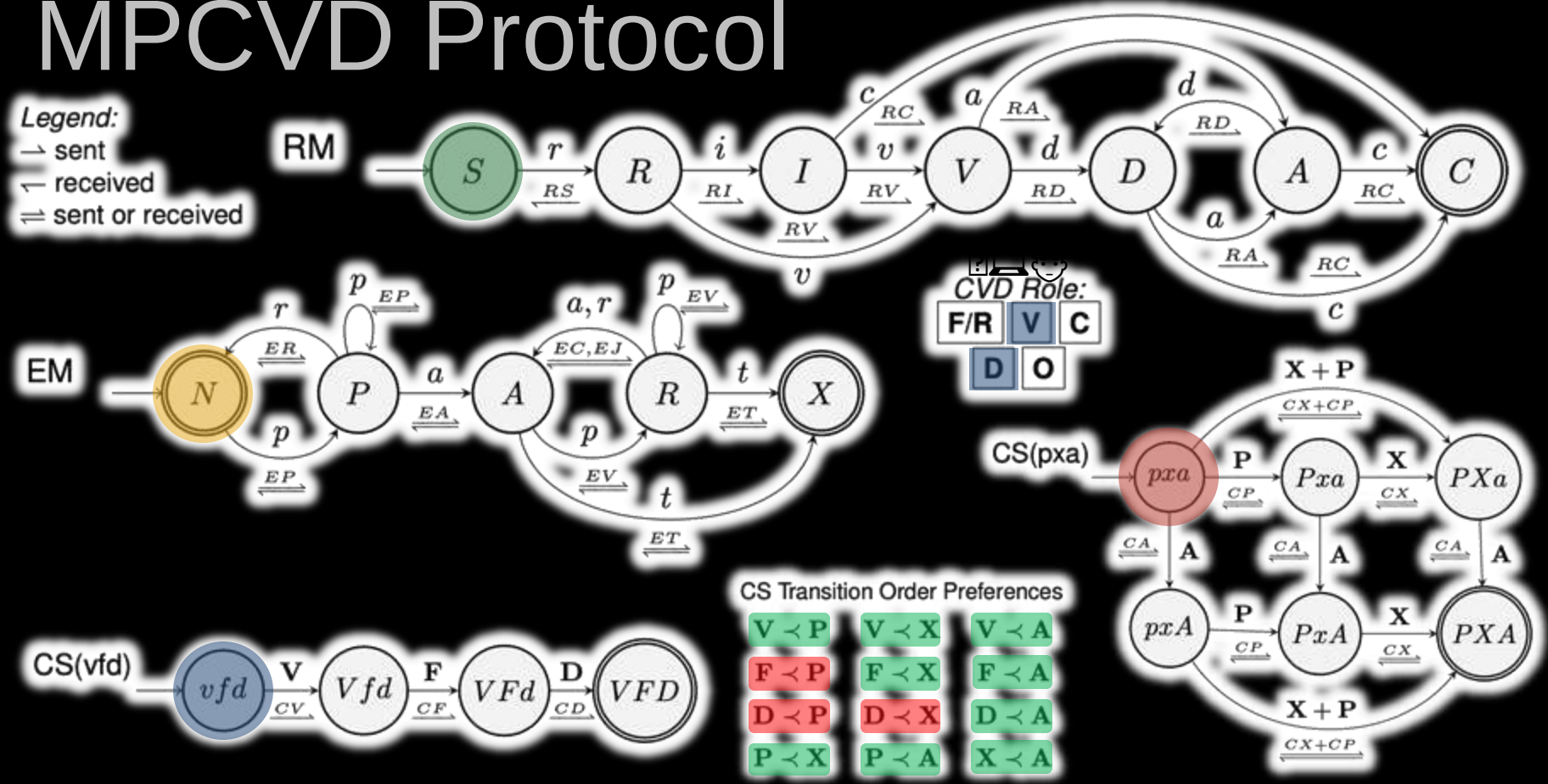
MPCVD Protocol



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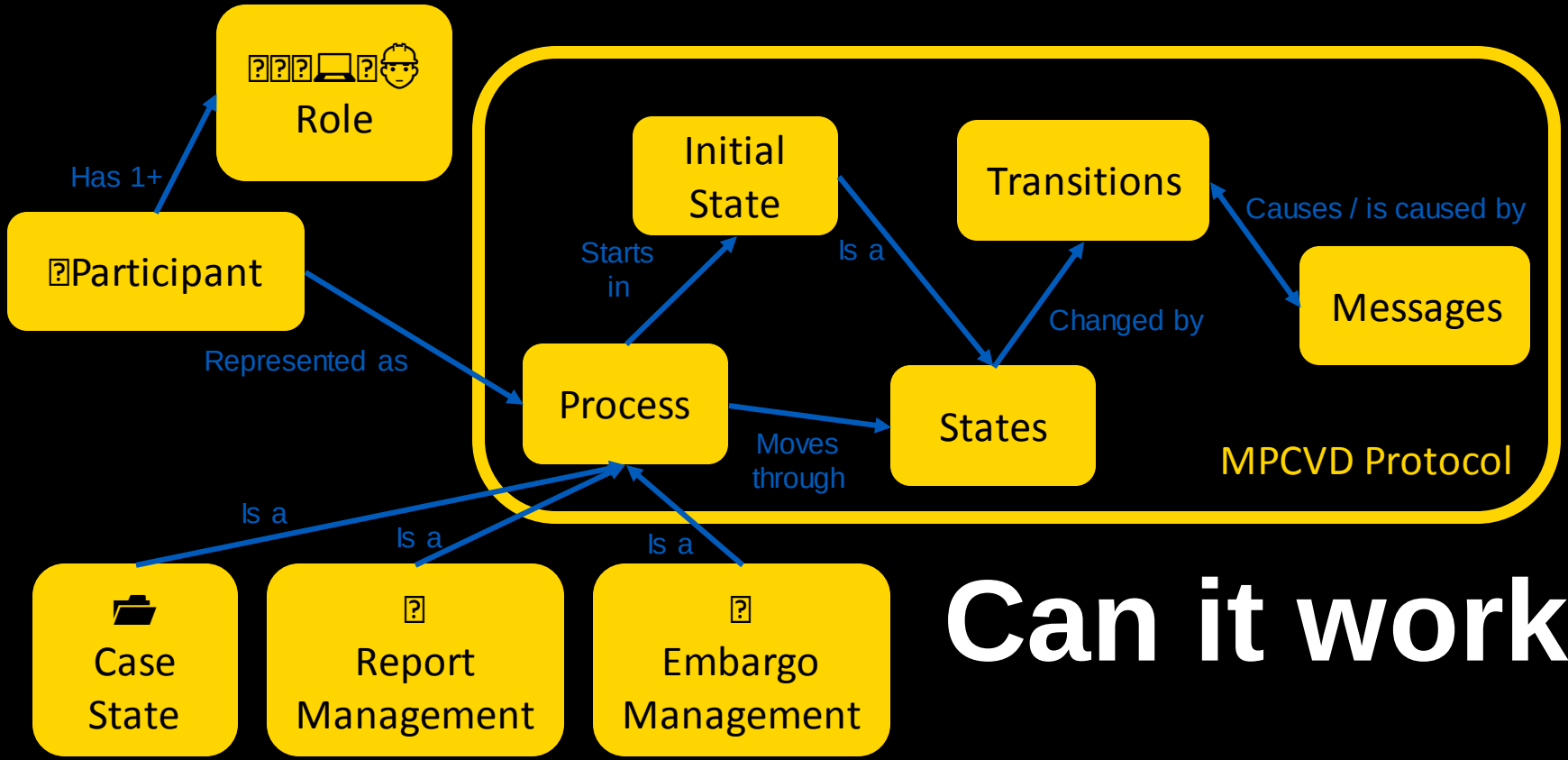

Can it work?

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Simulating Vultron

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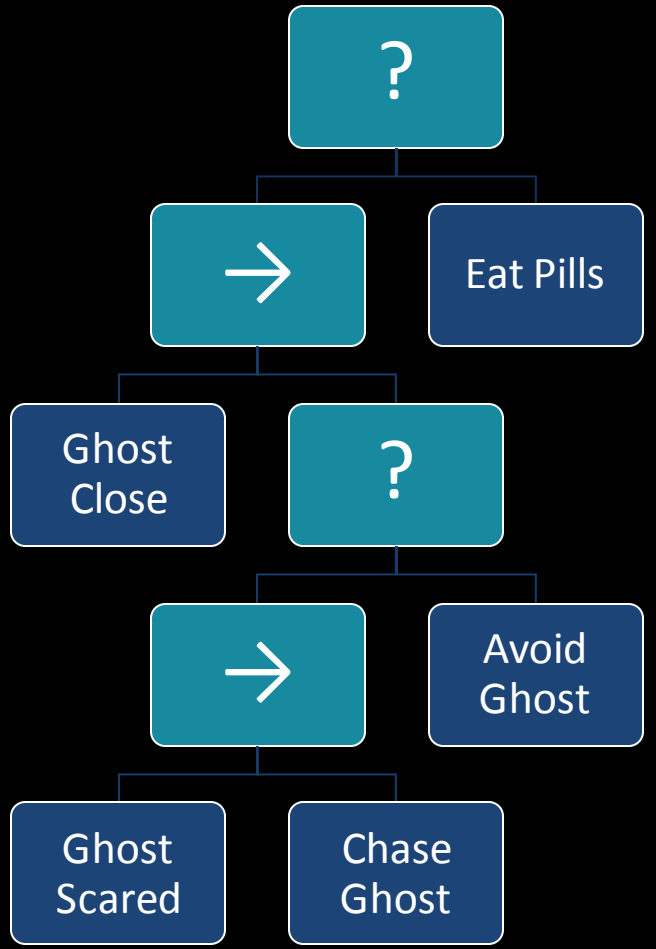
Behavior Trees

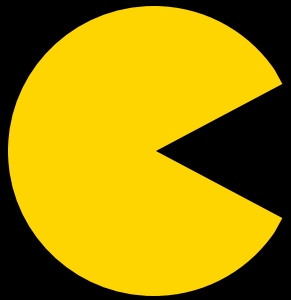
A method for designing autonomous agents

- Game AI / Non-Player Characters (NPCs)
- Robotics

Features

- Modularity / Composability
- Reactivity
- Generalize other ideas
  - Decision trees
  - Finite state machines





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Designing Vultron

Vultron Behavior

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MPCVD Protocol Behavior

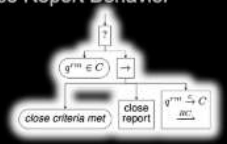
Discover Vulnerability Behavior

Receive Messages Behavior

Report Management Behavior

Validate Report Behavior

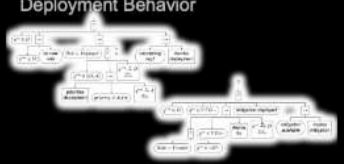
Close Report Behavior



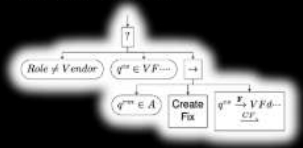
Prioritize Report Behavior

Do Work Behavior

Deployment Behavior



Develop Fix Behavior

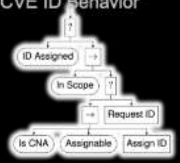


Monitor Threats Behavior

Reporting Behavior

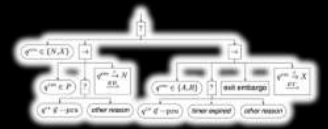
Publication Behavior

Assign CVE ID Behavior



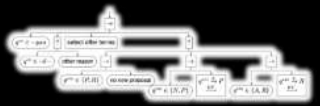
Acquire Exploit Behavior

Terminate Embargo Behavior

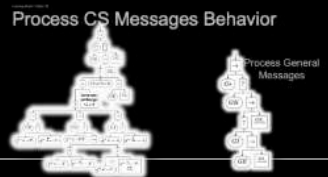


Embargo Management Behavior

Propose Embargo Behavior



Process CS Messages Behavior



Process RM Messages Behavior

Process EM Messages Behavior

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Demo

	q_rm	q_em	q_cs	messages_received	messages_sent
1	RM.START	EM.NO_EMBARGO	CS.vfdpxa	[]	[]
2	RM.START	EM.NO_EMBARGO	CS.vfdpxa	[RS, CV, RK, CK]	[RS, CV, RK, CK, RV]
3	RM.VALID	EM.NO_EMBARGO	CS.Vfdpxa	[RV, RK]	[RK, RA]
4	RM.ACCEPTED	EM.NO_EMBARGO	CS.Vfdpxa	[RA, CP, RK, CK]	[RK, CK]
5	RM.ACCEPTED	EM.NO_EMBARGO	CS.VfdPxa	[]	[CF]
6	RM.ACCEPTED	EM.NO_EMBARGO	CS.VFdPxa	[CF, CK]	[CK]
7	RM.ACCEPTED	EM.NO_EMBARGO	CS.VFdPxa	[]	[]
8	RM.ACCEPTED	EM.NO_EMBARGO	CS.VFdPxa	[]	[]
9	RM.ACCEPTED	EM.NO_EMBARGO	CS.VFdPxa	[]	[]
10	RM.ACCEPTED	EM.NO_EMBARGO	CS.VFdPxa	[]	[]
11	RM.ACCEPTED	EM.NO_EMBARGO	CS.VFdPxa	[]	[CD]
12	RM.ACCEPTED	EM.NO_EMBARGO	CS.VFDPxa	[CD, CK]	[CK, RC]
13	RM.CLOSED	EM.NO_EMBARGO	CS.VFDPxa	[CD, CK]	[CK, RC]

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Demo

	q_rm	q_em	q_cs	messages_received	messages_sent
1	RM.START	EM.NO_EMBARGO	CS.vfdpxa	[]	[]
2	RM.START	EM.NO_EMBARGO	CS.vfdpxa	[RS, CV, RK, CK]	[RS, CV, RK, CK, RV]
3	RM.VALID	EM.NO_EMBARGO	CS.Vfdpxa	[RV, RK]	[RK, RA]
4	RM.ACCEPTED	EM.NO_EMBARGO	CS.Vfdpxa	[RA, CP, RK, CK]	[RK, CK]
5	RM.ACCEPTED	EM.NO_EMBARGO	CS.VfdPxa	[]	[CF]
6	RM.ACCEPTED	EM.NO_EMBARGO	CS.VFdPxa	[CF, CK]	[CK]
7	RM.ACCEPTED	EM.NO_EMBARGO	CS.VFdPxa	[]	[]
8	RM.ACCEPTED	EM.NO_EMBARGO	CS.VFdPxa	[]	[]
9	RM.ACCEPTED	EM.NO_EMBARGO	CS.VFdPxa	[]	[]
10	RM.ACCEPTED	EM.NO_EMBARGO	CS.VFdPxa	[]	[]
11	RM.ACCEPTED	EM.NO_EMBARGO	CS.VFdPxa	[]	[CD]
12	RM.ACCEPTED	EM.NO_EMBARGO	CS.VFDPxa	[CD, CK]	[CK, RC]
13	RM.CLOSED	EM.NO_EMBARGO	CS.VFDPxa	[CD, CK]	[CK, RC]

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Demo

	q_rm	q_em	q_cs	messages_received	messages_sent
1	RM.START	EM.NO_EMBARGO	CS.vfdpxa	[]	[]
2	RM.START	EM.NO_EMBARGO	CS.vfdpxa	[RS, CV, RK, CK]	[RS, CV, RK, CK, RV]
3	RM.VALID	EM.NO_EMBARGO	CS.Vfdpxa	[RV, RK]	[RK, RA]
4	RM.ACCEPTED	EM.NO_EMBARGO	CS.Vfdpxa	[RA, CP, RK, CK]	[RK, CK]
5	RM.ACCEPTED	EM.NO_EMBARGO	CS.VfdPxa	[]	[CF]
6	RM.ACCEPTED	EM.NO_EMBARGO	CS.VFdPxa	[CF, CK]	[CK]
7	RM.ACCEPTED	EM.NO_EMBARGO	CS.VFdPxa	[]	[]
8	RM.ACCEPTED	EM.NO_EMBARGO	CS.VFdPxa	[]	[]
9	RM.ACCEPTED	EM.NO_EMBARGO	CS.VFdPxa	[]	[]
10	RM.ACCEPTED	EM.NO_EMBARGO	CS.VFdPxa	[]	[]
11	RM.ACCEPTED	EM.NO_EMBARGO	CS.VFdPxa	[]	[CD]
12	RM.ACCEPTED	EM.NO_EMBARGO	CS.VFDPxa	[CD, CK]	[CK, RC]
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Designing Vultron

What next?

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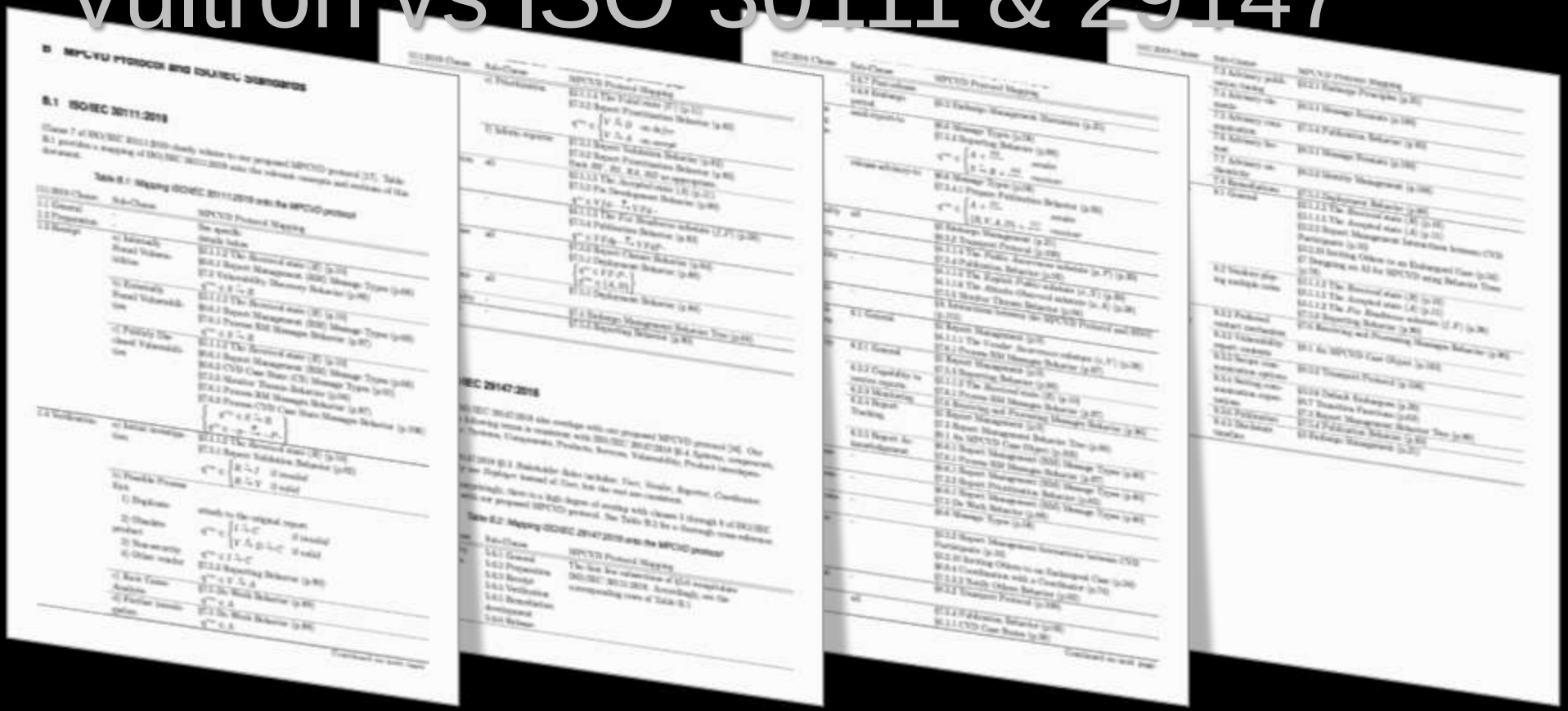
Vultron vs ISO 30111 & 29147



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Vultron vs User Stories

VALUE	FREQUENCY
Allowed	48
Unsupported	24
Provided	19
Out-of-scope	11

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Future Work

Continue prototype / simulator

Testing & Evaluation
- User stories & requirements
- Prototype software
- Tabletop exercises?

Build community

Incorporate concepts & logic into VINCE

Message Formats

Integration / Interoperability
- Ontology?

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Coming soon

- User stories doc
- Vultron SEI Special Report
- Vultron simulator code

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adh@cert.org

@__adh__

Feedback & collaboration opportunities

- Probably Github?
- Other venues?

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