Building Confidence in Self-Aware, Self-Expressive Systems

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Overview of this Talk

- Our Context: The EPiCS Project.
- Difficulties in Measuring Confidence.
- Our Ideas.
- Collaboration Prospects.
The EPiCS Project

Motivation and Theme

- Compute nodes are moving towards heterogeneous architectures.
- Distributed systems growing in size.
- Increasing levels of dynamics and uncertainty.
- Decentralised control and ownership.
- Application domains with divergent requirements in functionality, flexibility, performance, resource usage, costs, reliability, safety and security.
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Application Case Studies

- Heterogeneous compute cluster for financial modelling.
- Distributed smart cameras for safety and security.
- Interactive hypermusic for a joint music experience.
EPiCS: Questions and Approach

How can systems “meet” these divergent goals?

- Dynamic management of trade-offs at run-time,
- Almost certainly sub-optimal for a given problem instance.
- Use online learning and adaptation to reduce design-time overhead.
- Online algorithm selection w.r.t. node goals.
- Inter-node mechanisms drive global behaviour.
- Self-aware, self-expressive nodes.
EPiCS: Questions and Approach

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- Self-aware, self-expressive nodes.

How can we design systems to do this?
- Reference architectural framework.
- Benchmarking and validation strategy: scenarios and metrics.
- Application-specific adaptation primitives.
Working Definitions:
Self-awareness and Self-Expression

To be **self-aware** a node must:

- *Possess knowledge about its internal state (private self-awareness).*
- *Possess knowledge about its environment (public self-awareness).*
Working Definitions:
Self-awareness and Self-Expression

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Optionally, it might also:

- *Possess knowledge of its role or importance within the wider system.*
- *Possess knowledge about the likely effect of potential future actions / decisions.*
- *Possess historical knowledge.*
- *Select what is and is not relevant knowledge* (meta-self-awareness).
Working Definitions: Self-awareness and Self-Expression

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- Possess knowledge about its internal state (**private self-awareness**).
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Optionally, it might also:

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- Possess historical knowledge.
- Select what is and is not relevant knowledge (**meta-self-awareness**).

A node exhibits **self-expression** if it is able to assert its behaviour upon either itself or other nodes. This behaviour is based upon the node’s state, context, goals, values, objectives and constraints.
Difficulties in Measuring Confidence

Issues we are facing:

- Highly dynamic: “optimal” behaviours and context both change.
- Complex interactions and feedback loops between nodes.
- Humans may be in the loop.
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In this scenario, we aim to perform meaningful and useful adaptation. How can we claim that this will happen?

- We have well understood techniques for evaluating and comparing learning algorithms on static problems.
- We are beginning to develop taxonomies for types of changes in dynamic problems.
- But to what extent can we make claims about unpredictable dynamics and problem instances in open self-aware systems?
A Case Study: Handover in Distributed Smart Camera Networks
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From L. Esterle, P. R. Lewis, M. Bogdanski, B. Rinner and X. Yao

A Socio-Economic Approach to Online Vision Graph Generation and Handover in Distributed Smart Camera Networks

A Case Study:
Handover in Distributed Smart Camera Networks

![Graph showing total utility versus communication for active and passive approaches.](image)
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A Single Problem Instance

Attribute 1

Attribute 2

1 2 3 4 5
Problem Instances at a Point in Time

Concept

Topology

f

3 nodes
Problem Instances at a Point in Time

Concept

3 nodes 5 nodes

Topology

f' f

1 2
Problem Instances at a Point in Time

Concept

3 nodes 5 nodes

Topology

f'
f

f

3 nodes 5 nodes
Problem Instances at a Point in Time

Concept vs. Topology

3 nodes 5 nodes

f f'

1 2 3 4
The Space of Relevant Problem Instances

Concept

Topology

3 nodes

5 nodes

f'

f

1

2

3

4
Types of Dynamics

Concept Drift

Small change

1 new node / minute

Topology changes
Types of Dynamics

- Concept Drift
- Topology changes

- Larger change
  - 1 new node / minute
  - 2 new nodes / minute

- Small change
Types of Dynamics

- Larger change
- Small change

Concept Drift vs. Topology changes

- 1 new node / minute
- 2 new nodes / minute
The Space of Relevant Dynamics

- Concept Drift
- Topology changes

1 new node / minute
2 new nodes / minute

Larger change
Small change
Putting it Together

Diagram: Concept vs Topology

- Nodes labeled 1, 2, and 3 are connected with arrows indicating relationships.
Putting it Together

Concept × Topology changes

Concept

Topology

Concept Drift

Topology changes
Putting it Together

Concept × Topology changes

Attribute 1

Attribute 2
Summary and Some Questions

So... In order to make claims about what self-aware systems will or will not do, we need to know what the scope of the claims is.
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- Problem instances,
- Dynamics,
- Other things?
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What Next?
- Does this make sense?
- What else should be included?
- How can we formalise this?
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Apologies if this is all very obvious, but...

“[Our new technique] is beneficial for the performance of [the algorithm] in dynamic environments”.
Thanks for listening.

http://www.epics-project.eu/