Emergent Distributed Bio-Organization: A Framework for Achieving Emergent Properties in Unstructured Distributed Systems

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Outline

- Complexity and Traditional Engineering
- A Framework for Harnessing Emergent Properties
- EDBO: Applying the Framework in Practice
  - Hypothesis and implanted behaviour
  - Expected emergent behaviour
  - Preliminary results
- Discussion & Next Steps

The Ever Increasing Complexity…

- Hundreds of **billions** of CPUs already in products
  - **PCs** represent less than **1%** of those (*Ganssle Group)*
- Self-driving cars, unmanned autonomous aircrafts, autonomous spaceship swarms…
- **Healthcare**, **e-voting**, **transportation**, **military**
- And a 100$ phone nowadays has **twice** the computational power of last decade's PCs

And the Ever Increasing Connectivity

- More than **2B Internet users**
- *Cisco* predicts the "Internet Boom": **more than 15B devices on Internet by** 2015
- Mobile Internet, **Internet of things**, PANs …

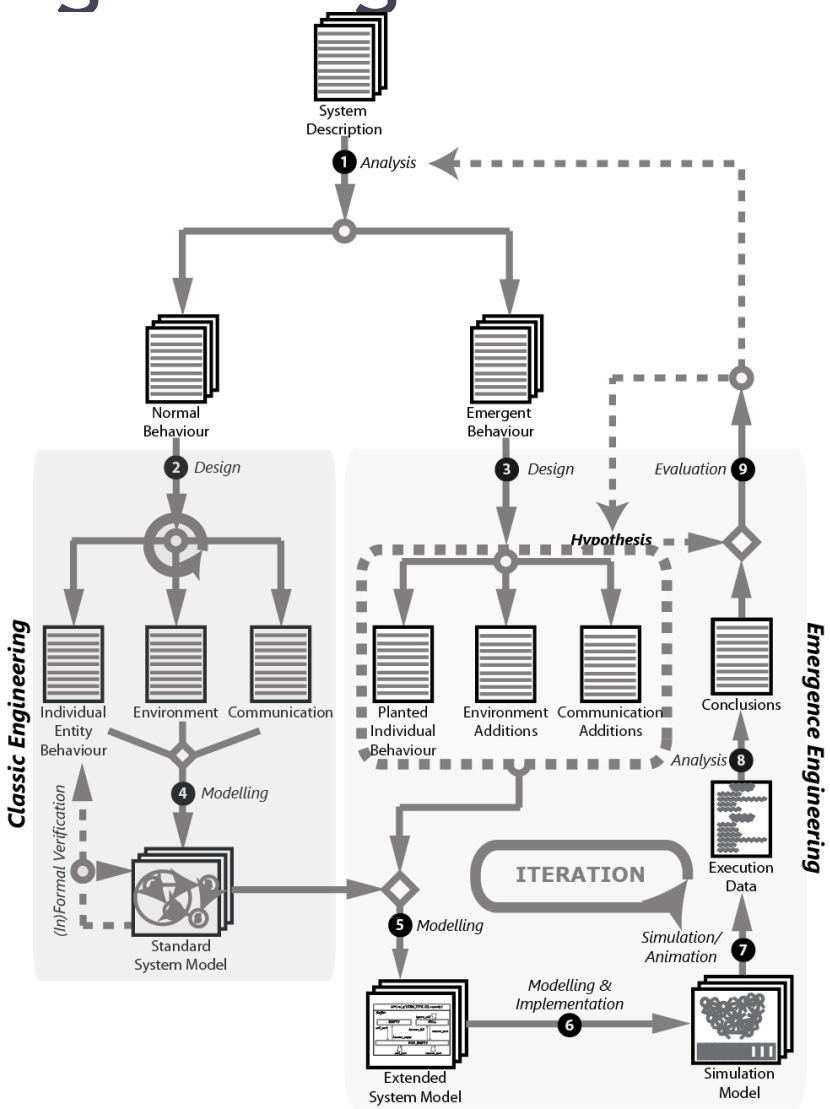
Can *Traditional Engineering Cope* with That?

- Need for (re) configuration, deployment, management, maintenance…
- And **resilience** should the *environment or business needs change*
- **Will traditional engineering techniques be able to cope with such unprecedented levels of complexity?**
  - *Will we have the necessary human resources and the required skills to tackle such complexity?*

Tackling the Complexity *Implicitly*

- **Emergence** in natural systems is responsible for many beneficial properties:
  - *Adaptability, self-healing, self-organization, self-**
- Artificial systems could greatly benefit (or suffer) from emergent properties
- Controlling emergence could provide an **implicit way** to engineer complex systems and behaviours
  - By focusing solely on the microscopic level

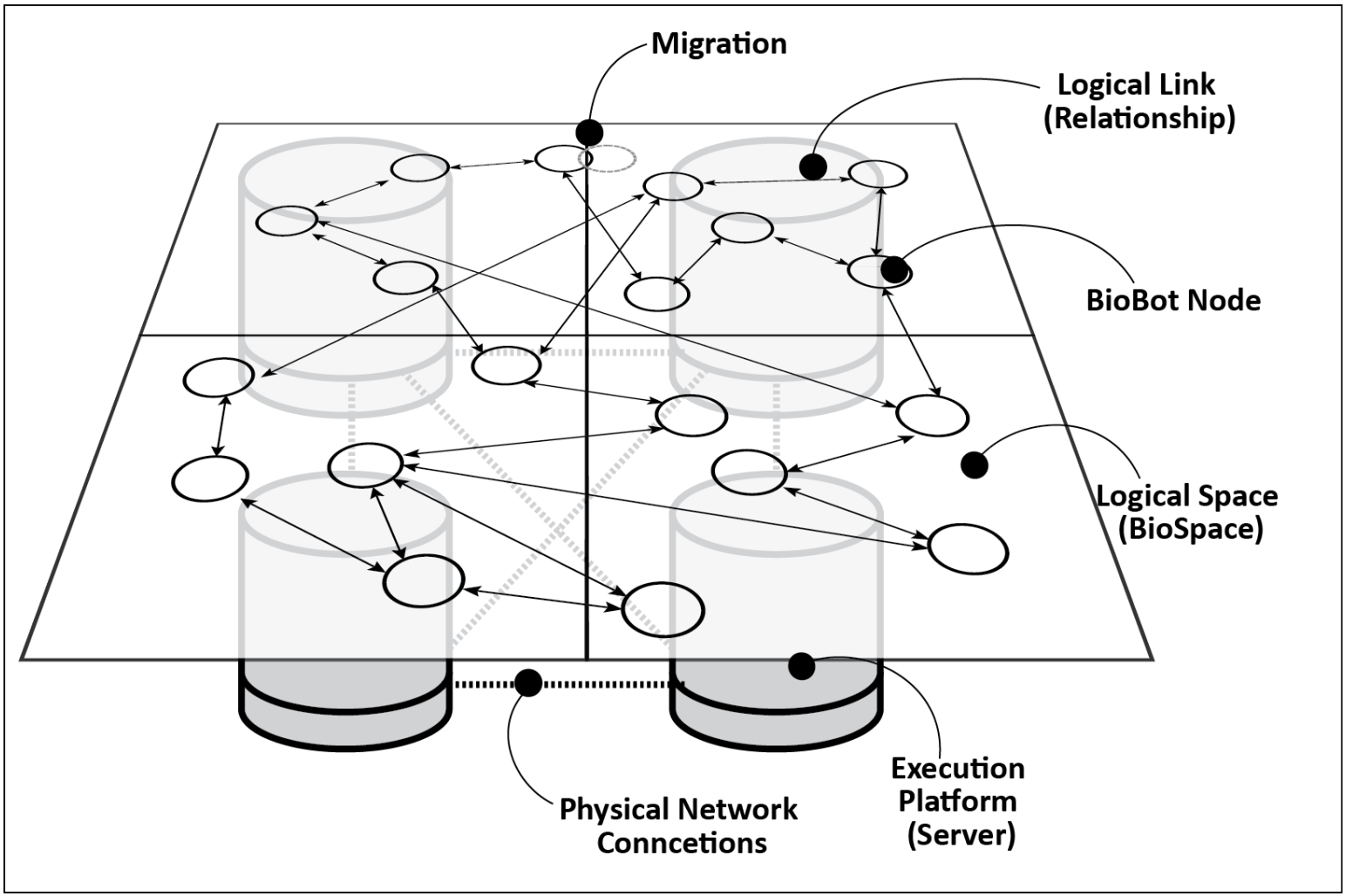
An Experimental Framework for Harnessing Emergence in ADS



The Emergent Distributed Bio-Organization Paradigm (EDBO)

- A **generic** distributed systems paradigm
  - Not a specific instantiation, could be used to model P2P file sharing, Web Services, etc.
- Nodes are referred to as **BioBots**
- Each BioBot acts as service provider & consumer
- Services are located through a **distributed query forwarding mechanism**
- BioBots are situated in the **BioSpace**

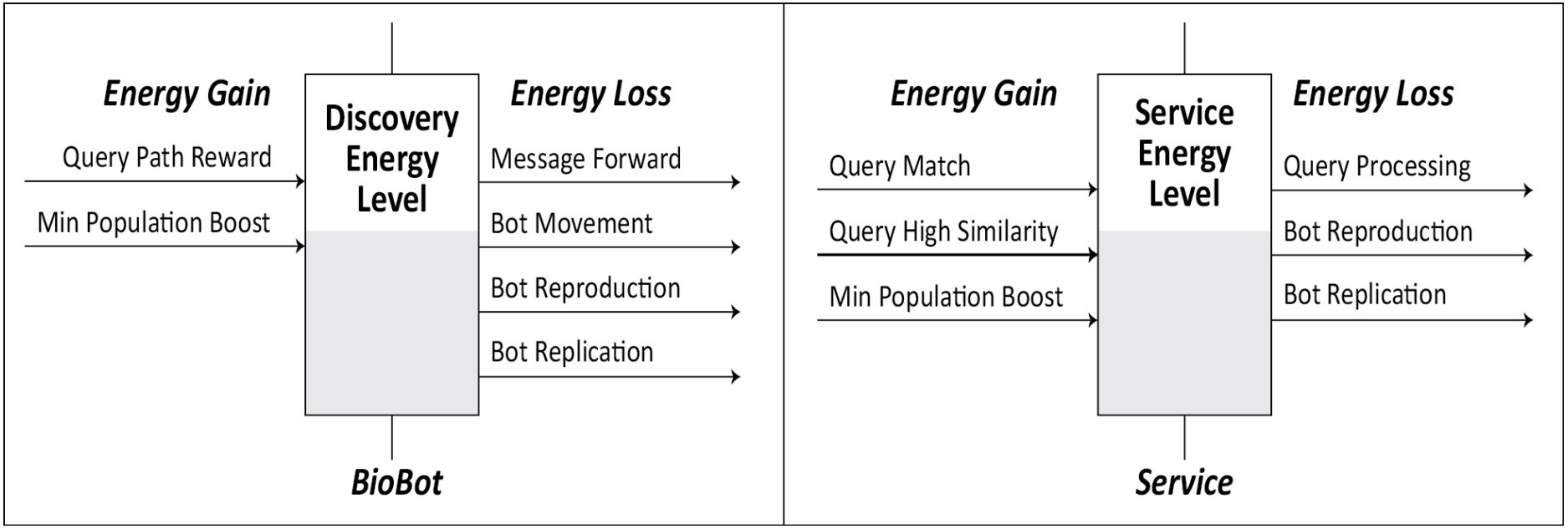
EDBO – Component Overview



Key Characteristics of EDBO

- **Bio-inspired properties and functions**
- Each BioBot possesses **2 energy levels**
  - **Discovery Energy**
  - **Service Energy** (per *service instance*)
- Energy is **fluctuating** as BioBots are being rewarded or expend different amounts of energy
- BioBots with high energy are able to perform special (bio-inspired) functions
- BioBots without energy are removed from the system (node death)

Different Energy Gain and Loss Scenarios



Expected Emergent Properties & Preliminary Results

- **Network Scalability** – adapt to very dynamic service demand peaks
- **Robustness** and **Availability** – overall connectivity maintained to satisfactory levels
- **Super-node formations** – although initially the network was completely unstructured

Next Steps

- **Separate** case study from simulation platform
- Precisely **document** the case study
- Allow results to be **reproducible**
- **Cross-validate** simulation results with these from a well-accepted, separate platform

Thank you for your time

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