A Brief History of Amorphous Computing

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April, 2007

Motivation: Organization

From the amorphous computing manifesto:

- How do we obtain coherent behavior from the cooperation of large numbers of unreliable parts that are interconnected in unknown, irregular, and time-varying ways?
- What are the methods for instructing myriads of programmable entities to cooperate to achieve particular goals?

*The problem is **description***

What is a Language?

- Standardized library of parts **[Primitives]**
- Rules for building bigger parts by combining smaller parts **[Composition]**
- Mechanism for naming parts and treating them like primitives. **[Abstraction]**

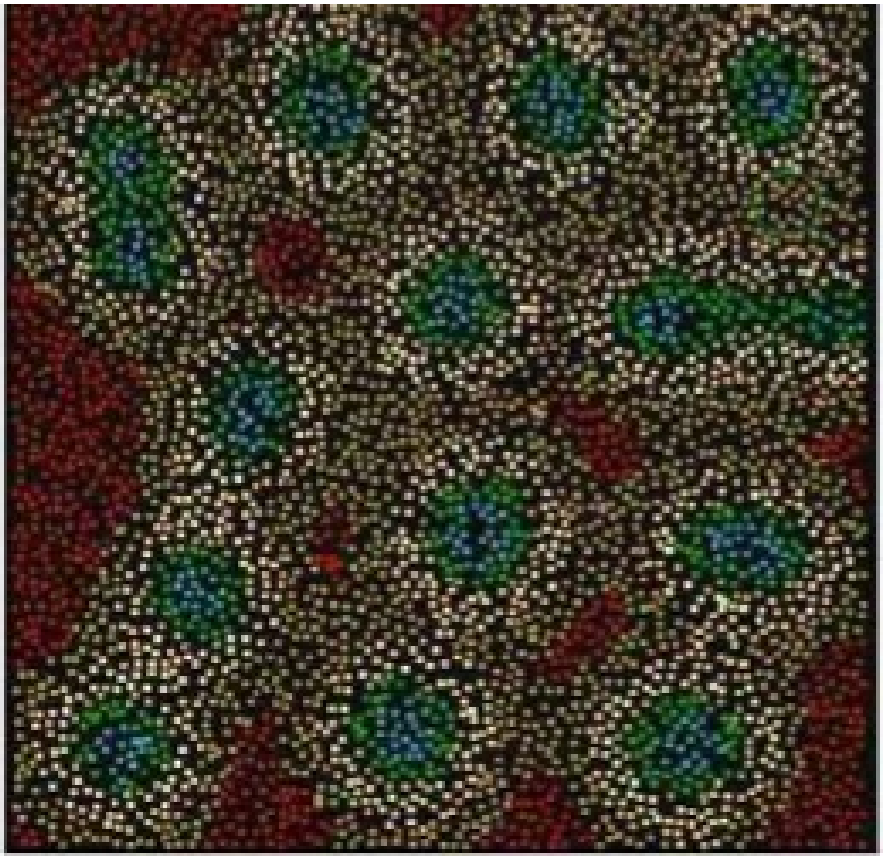
What is explicit and what is implicit?

Four Themes

- Physics: reaction-diffusion, wave equations, turing patterns, population dynamics
- Infrastructure: firefly time synch, coordinate systems, clustering
- Morphogenesis: MCL, GPL, OSL, 2D shape growth
- Engineering: Paintable Computing, Persistent Nodes, AML, Proto

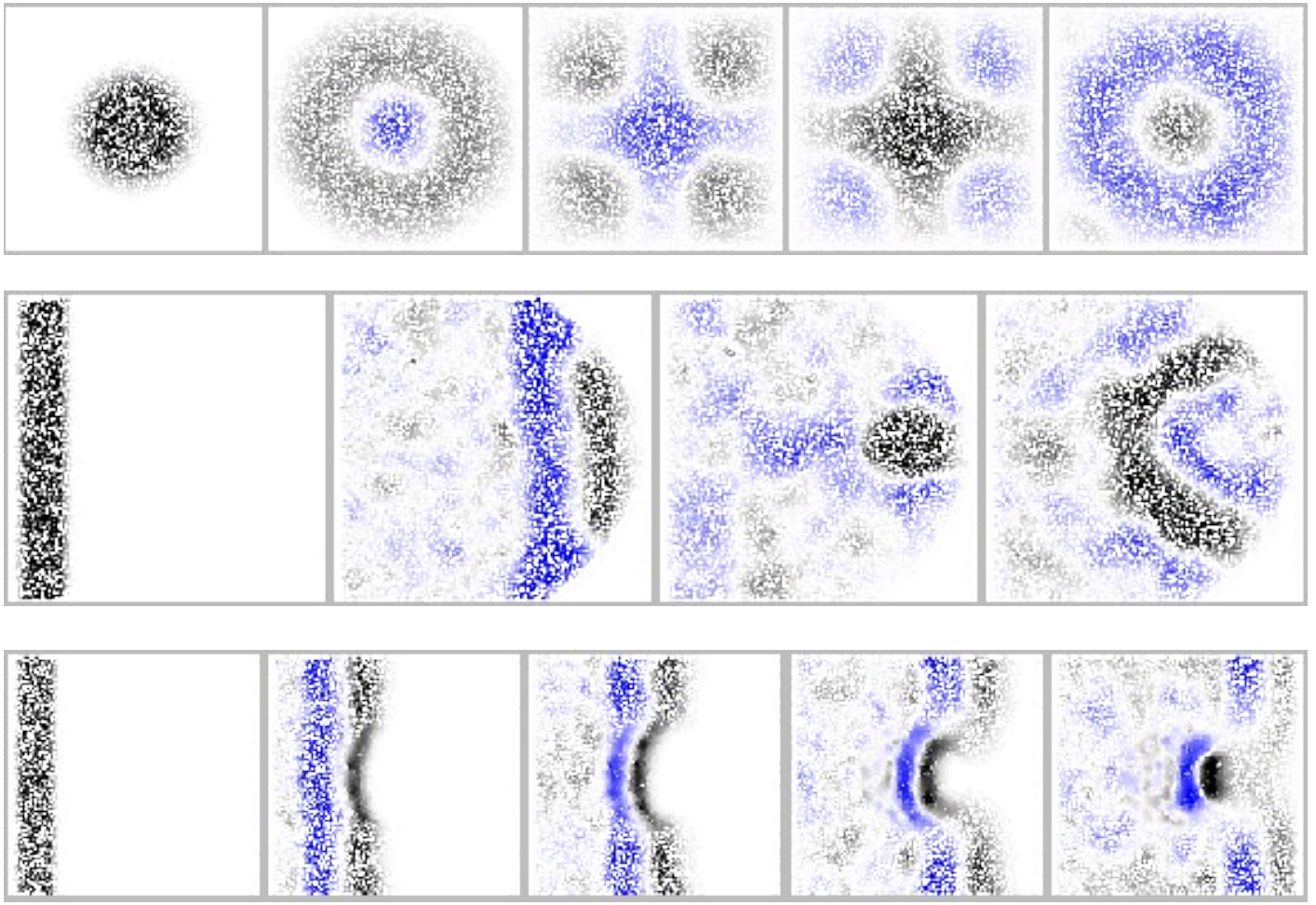
Physics: PDEs

- Reaction-Diffusion (Coore & Nagpal, 1998)



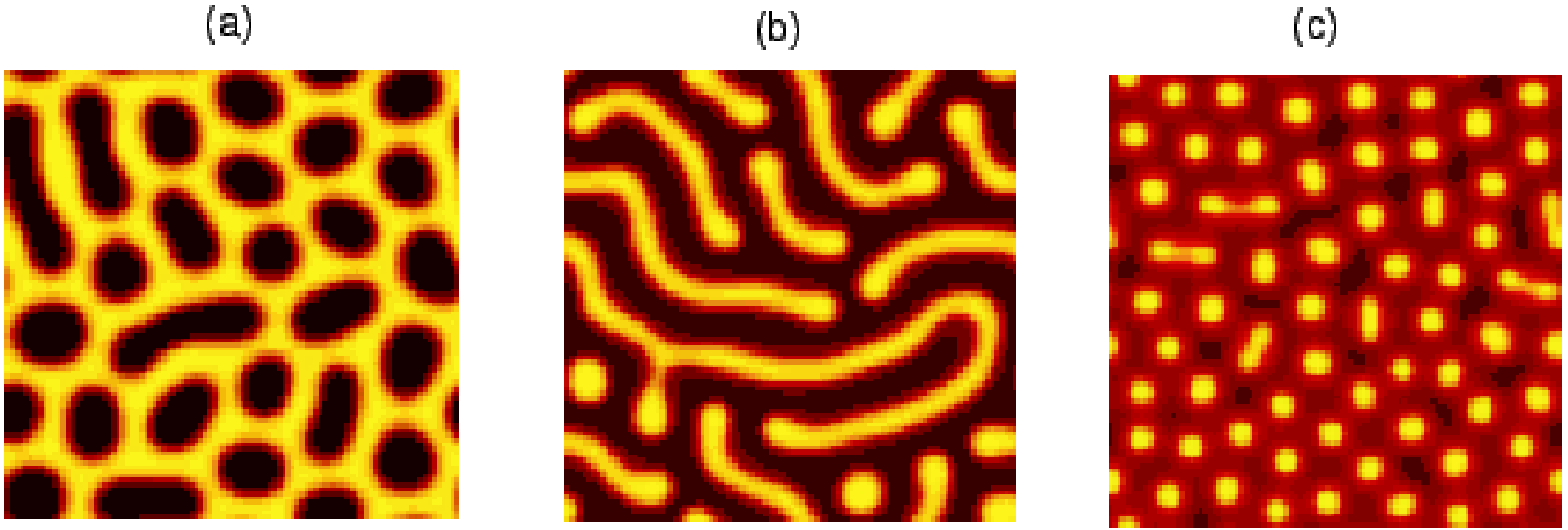
Physics: PDEs

- Wave Equation (Rauch, 1999)



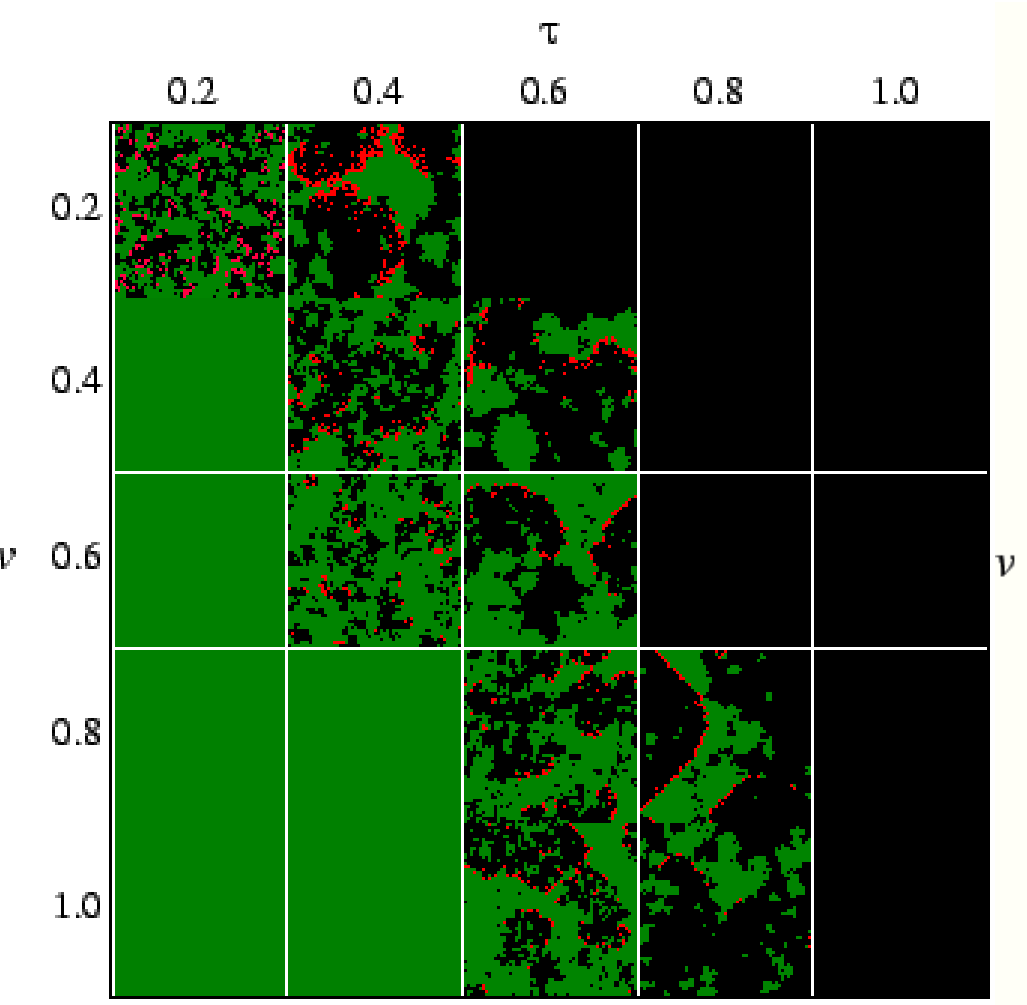
Physics: PDEs

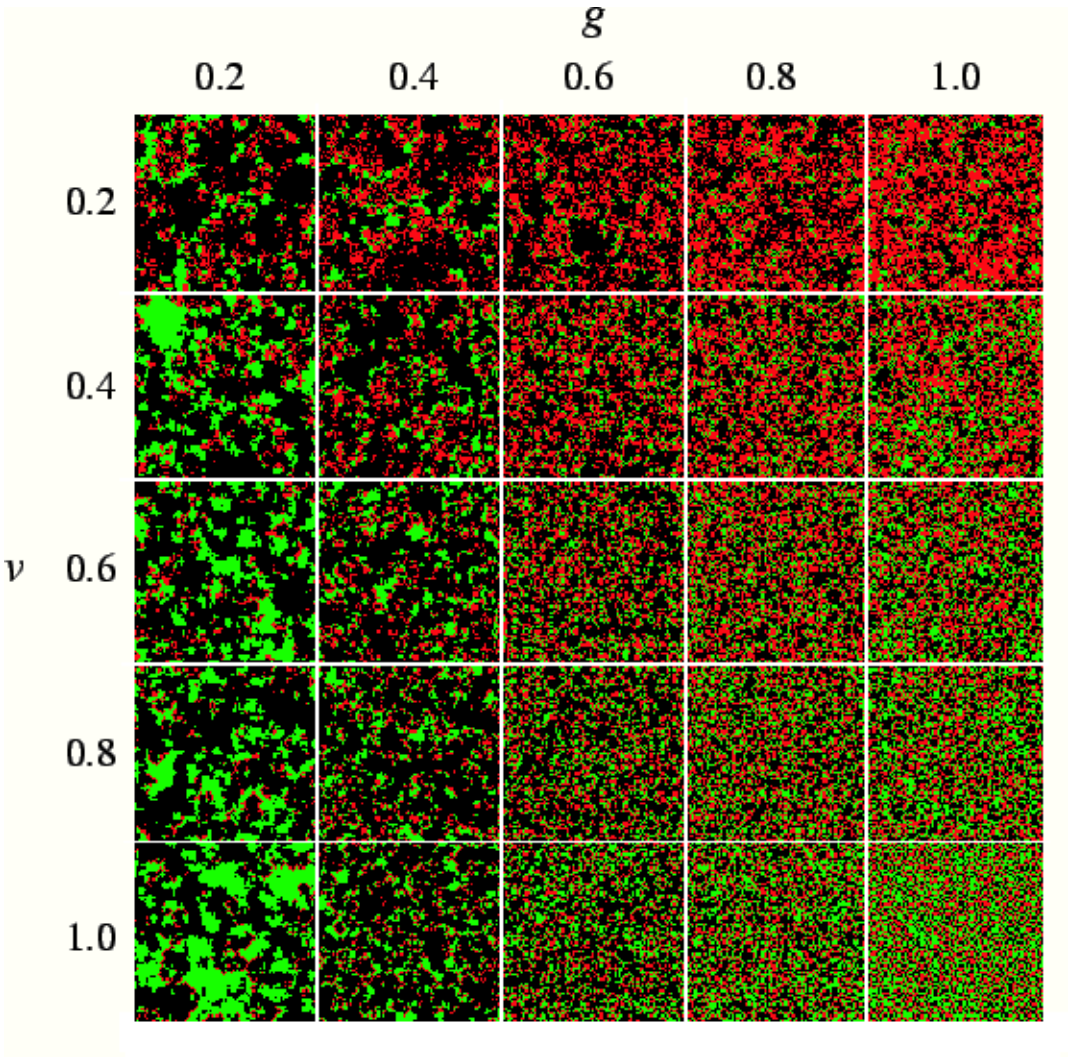
- Biologically plausible Turing Patterns (Rauch & Millonas, 1999)



Physics: Population Dynamics

- Group Evolution (Rauch, 2002)



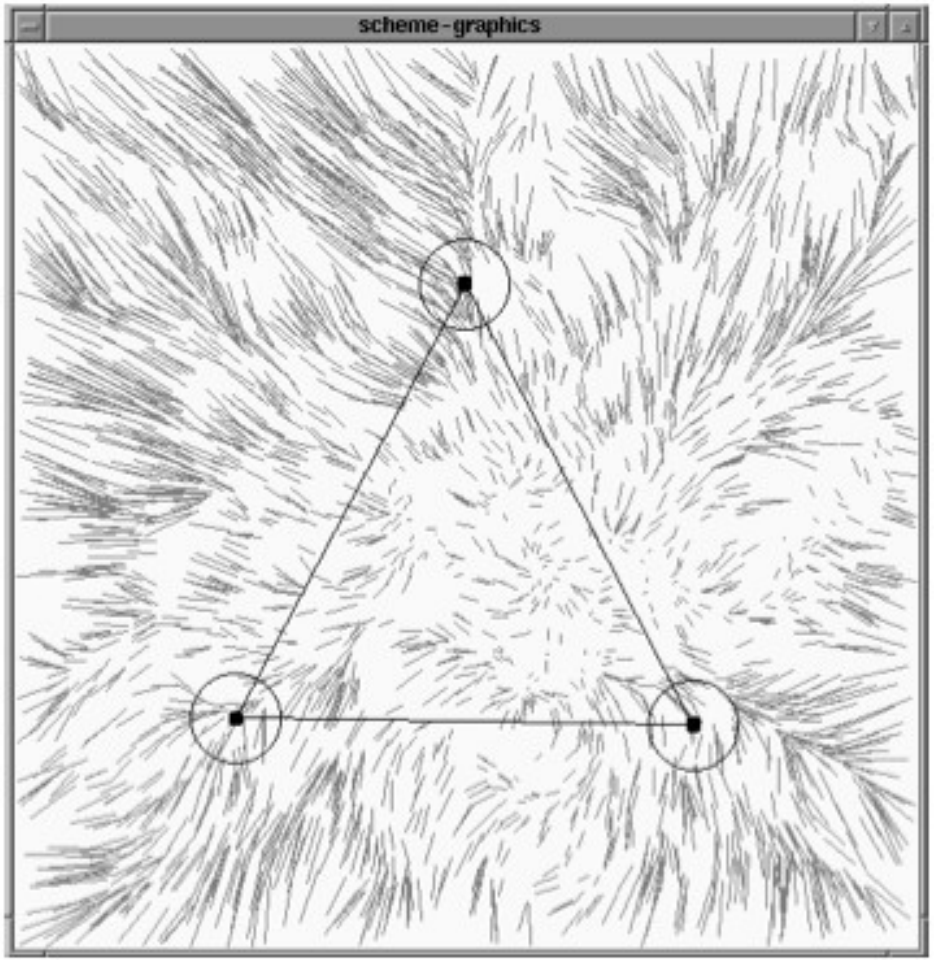


Infrastructure: Time Synch

- Strogatz firefly demo (Beebee, 1998)

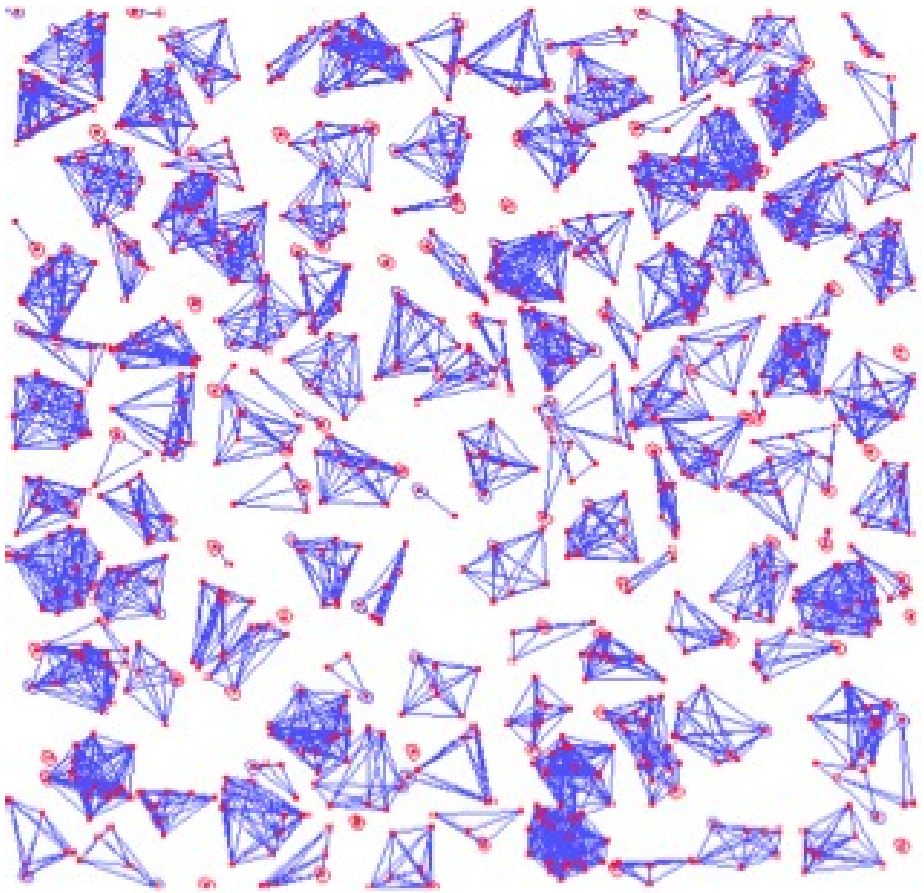
Infrastructure: Coordinates

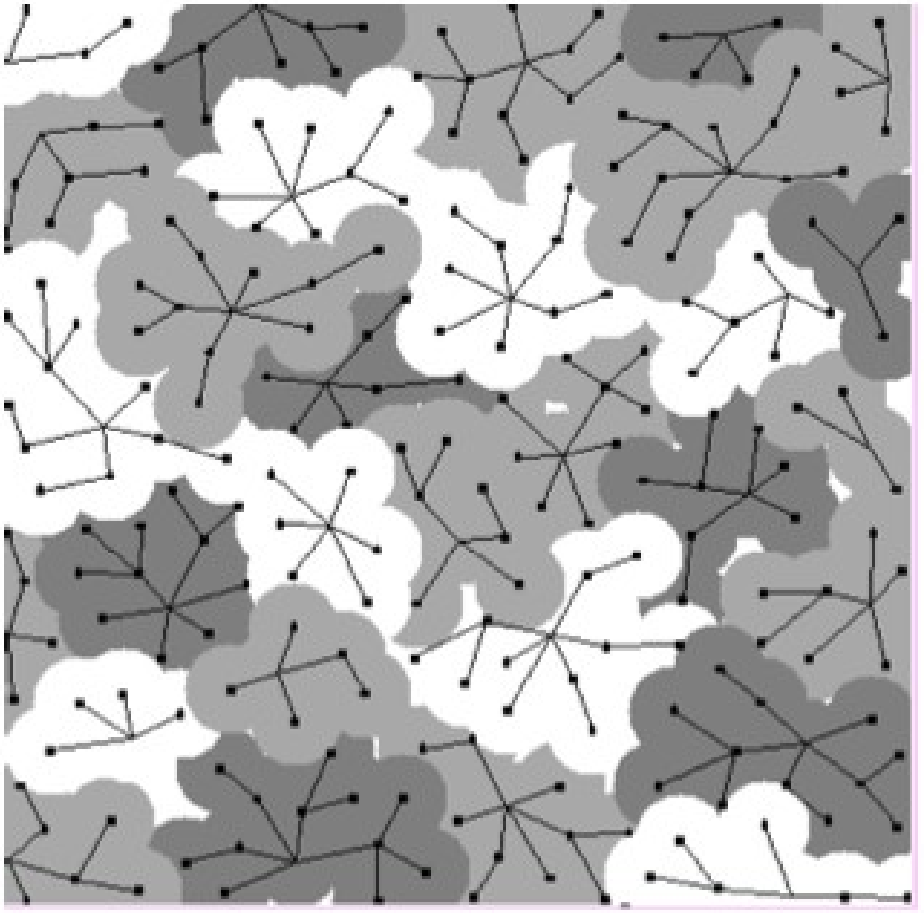
- (Coore, Nagpal, Shrobe, Bachrach)



Infrastructure: Groups

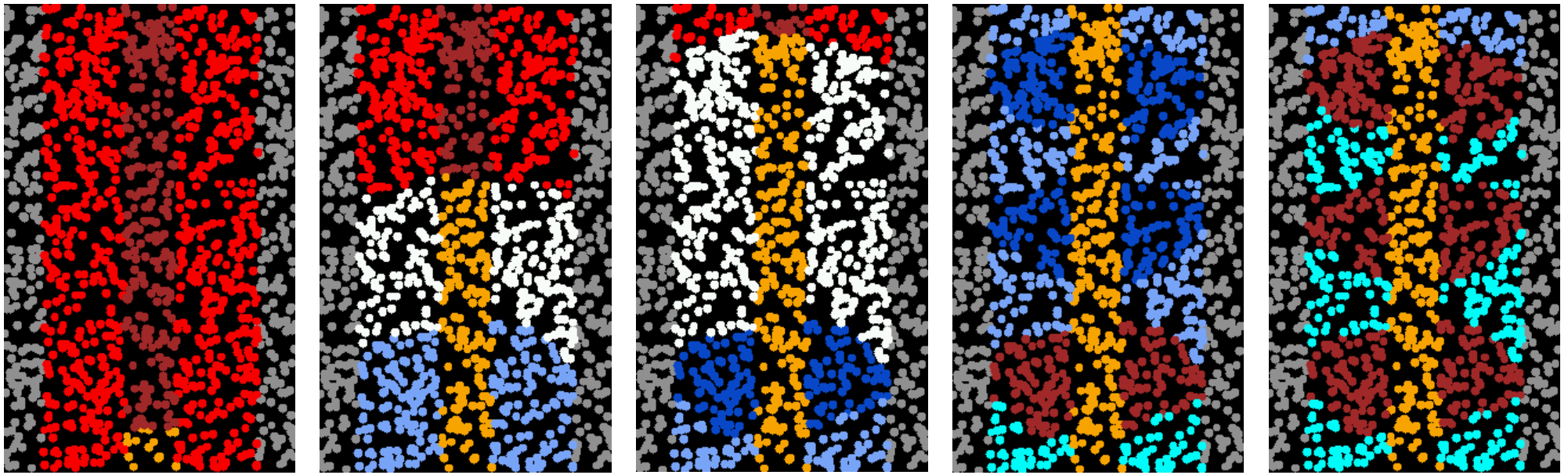
- Clubs algorithm (Coore, Nagpal, Weiss)





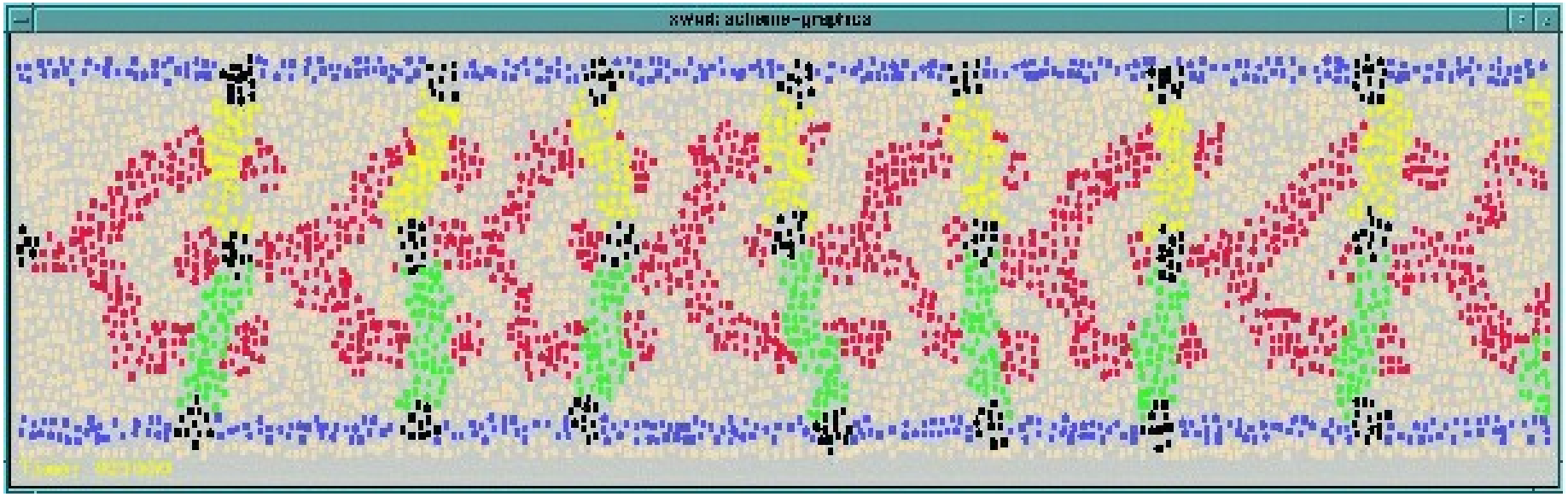
Morphogenesis

- Microbial Colony Language (Weiss, Homsy & Nagpal, 1998)



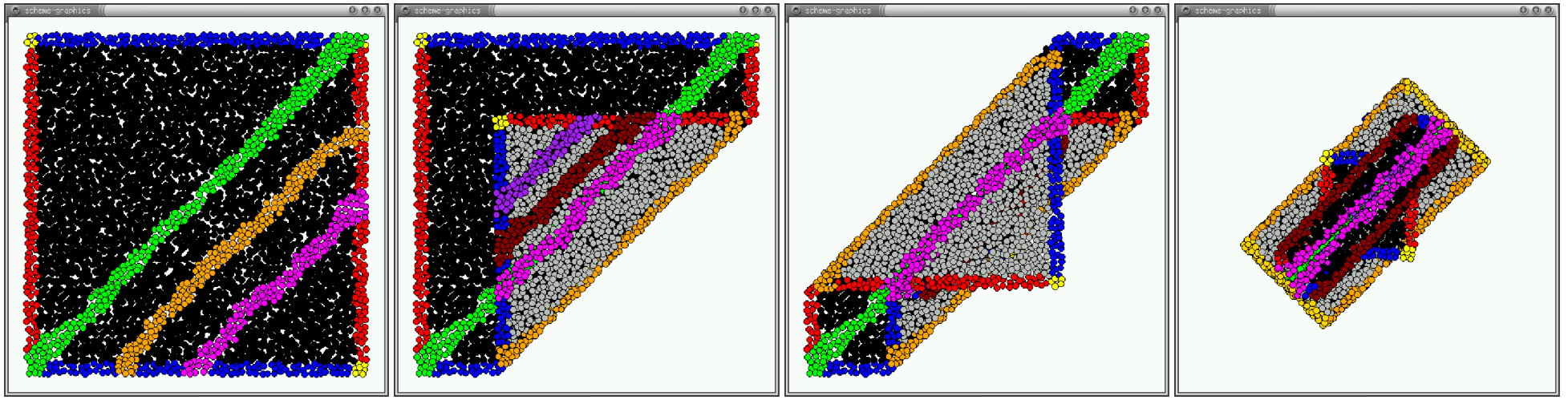
Morphogenesis

- Growing Point Language (Coore, 1999)



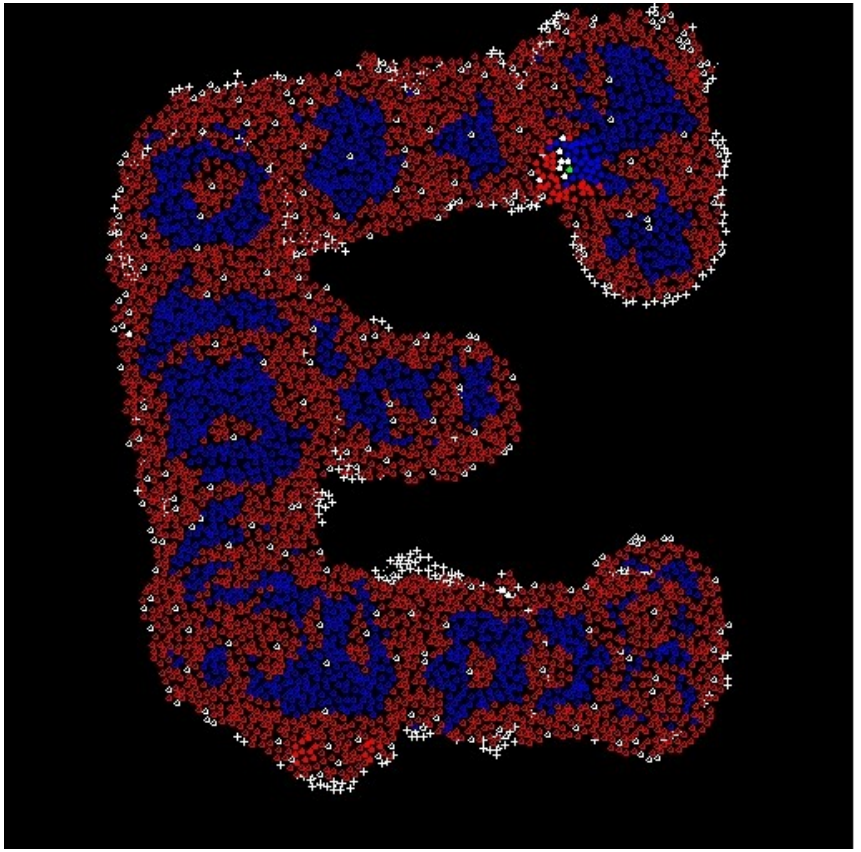
Morphogenesis

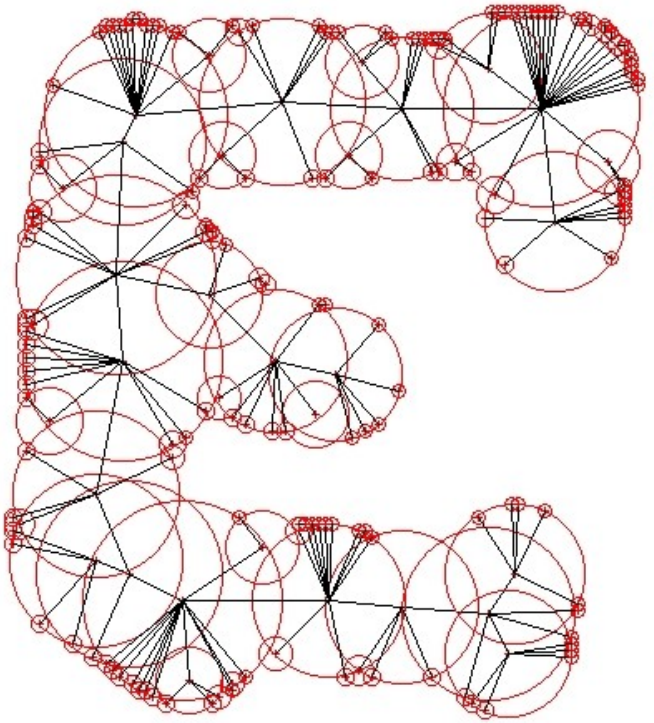
- Origami Shape Language (Nagpal, 2001)



Morphogenesis

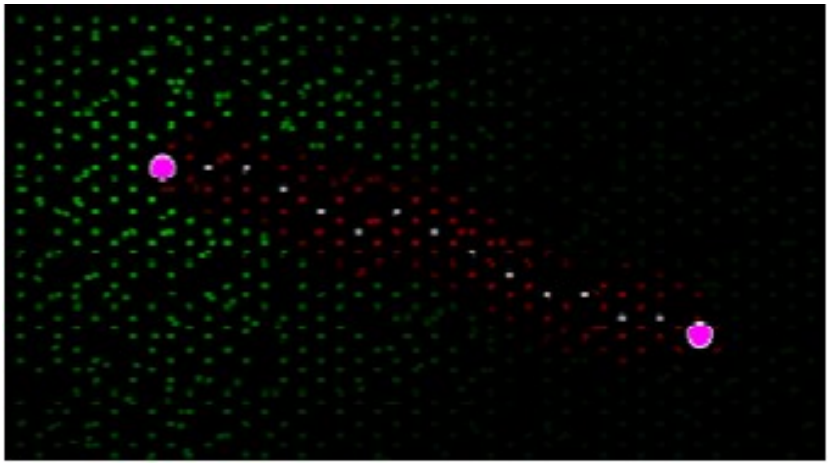
- 2D Shape Growth (Kondacs, 2003)

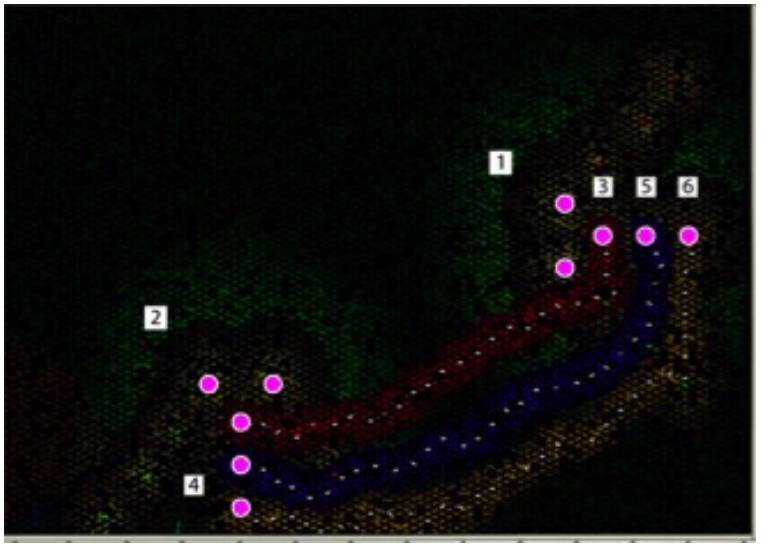


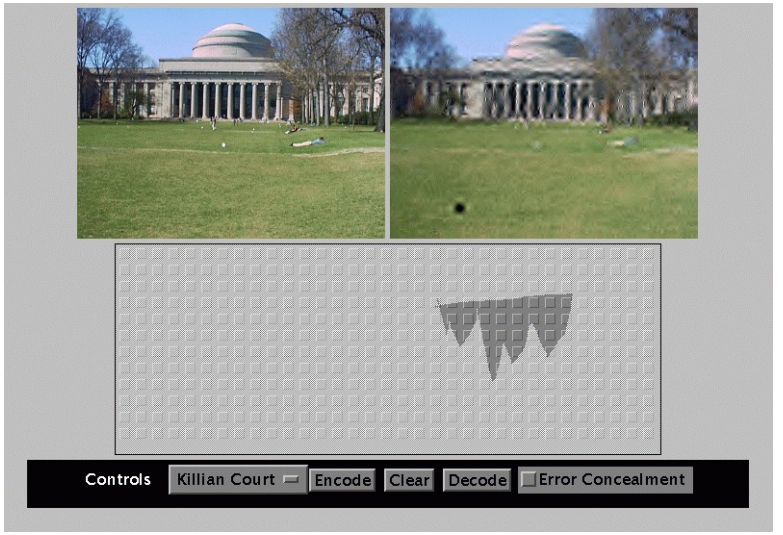


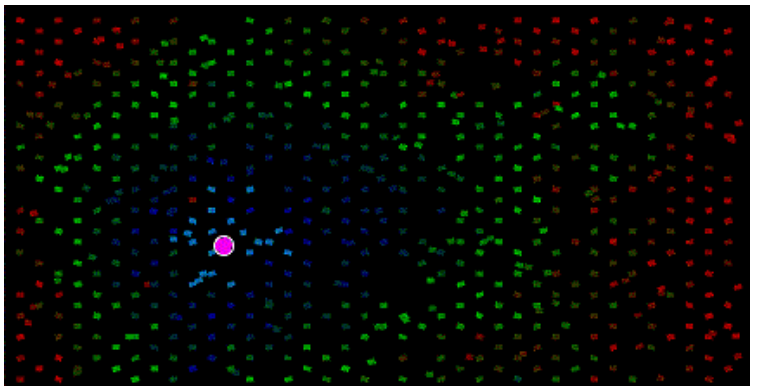
Engineering

- Paintable Computing (Butera, 2001)



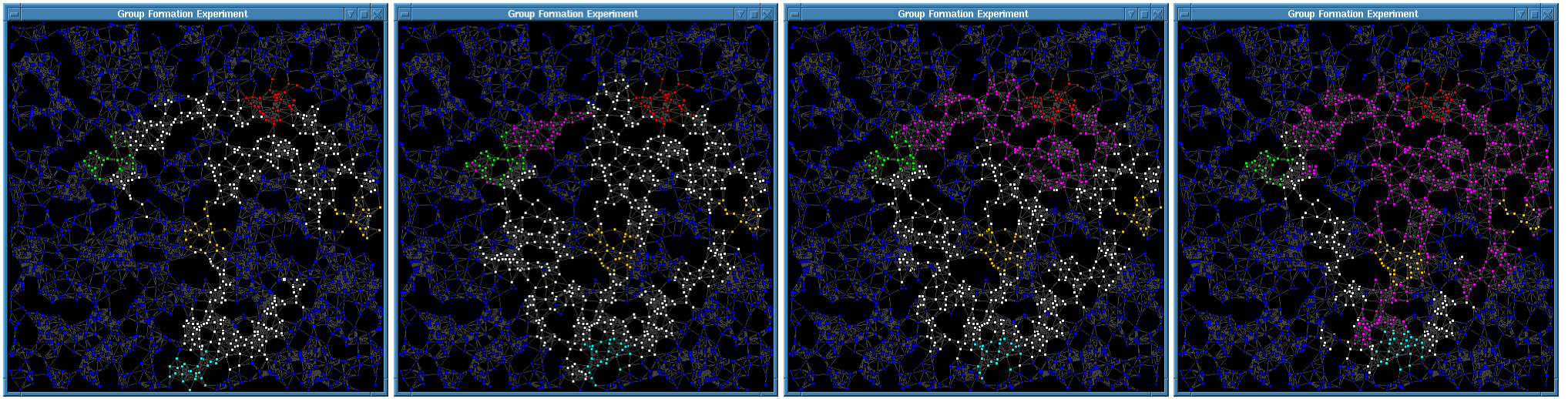






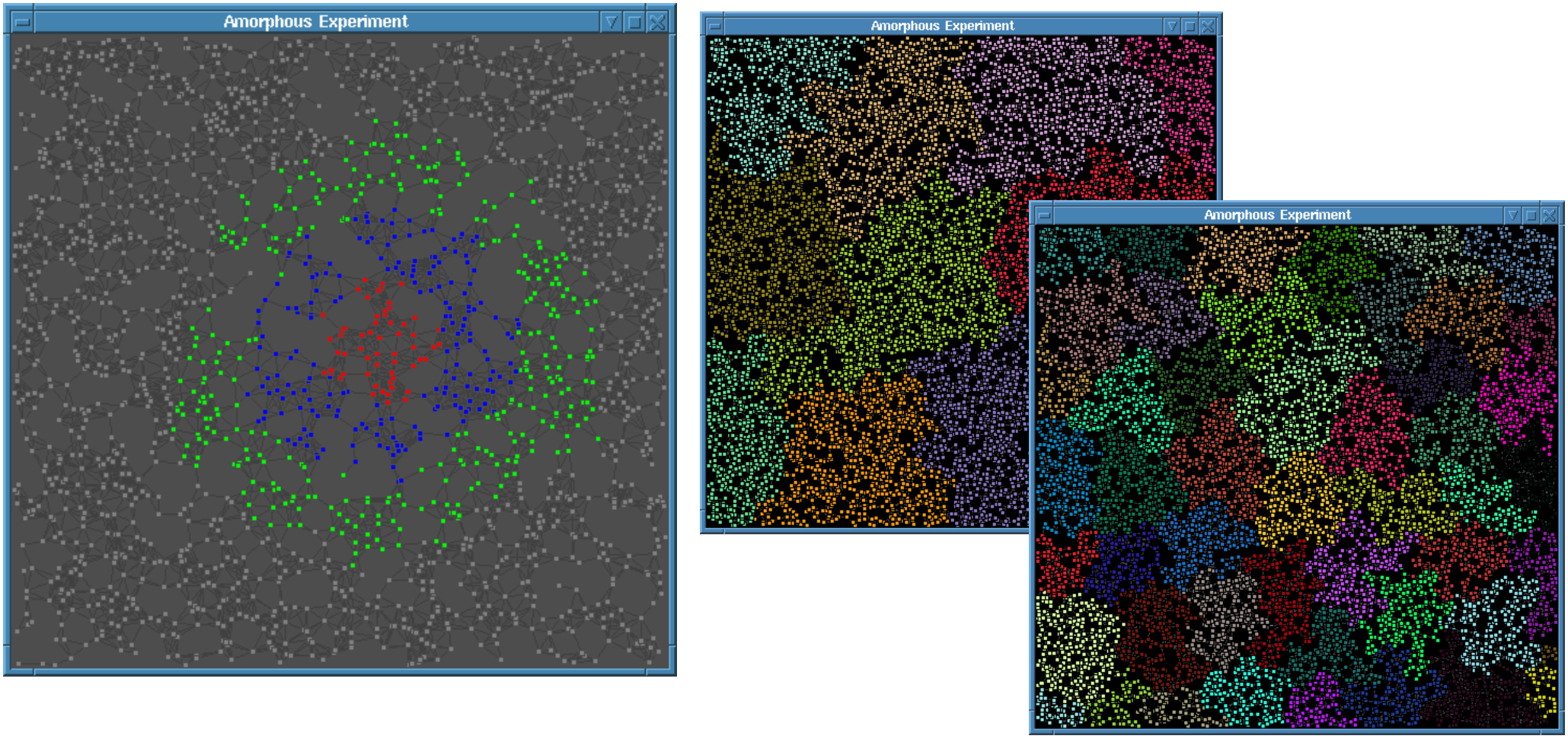
Engineering

- Dataflow Hack (Beal & Newton, 2002)



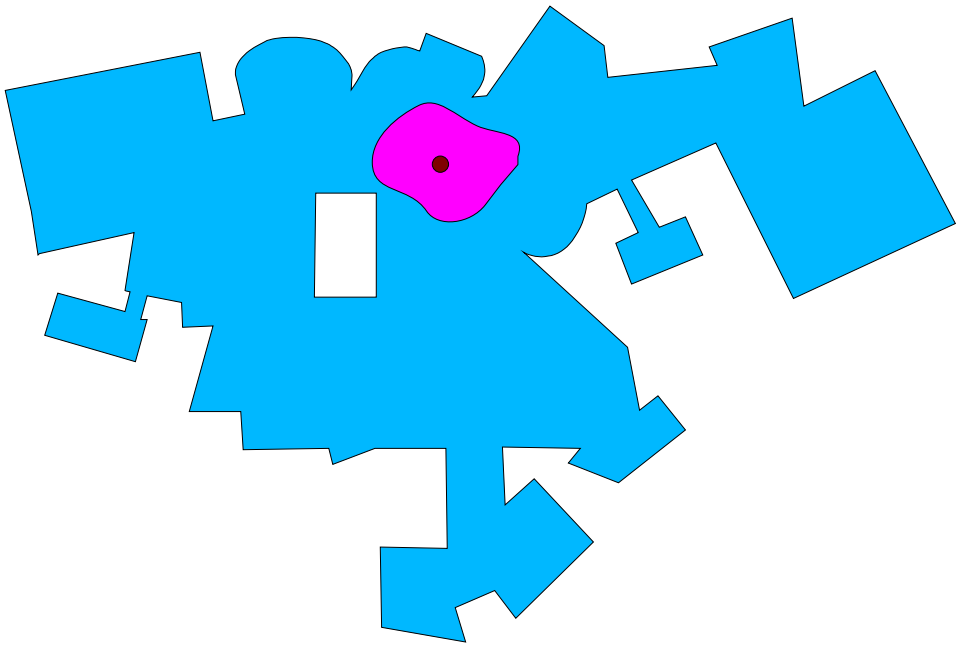
Engineering

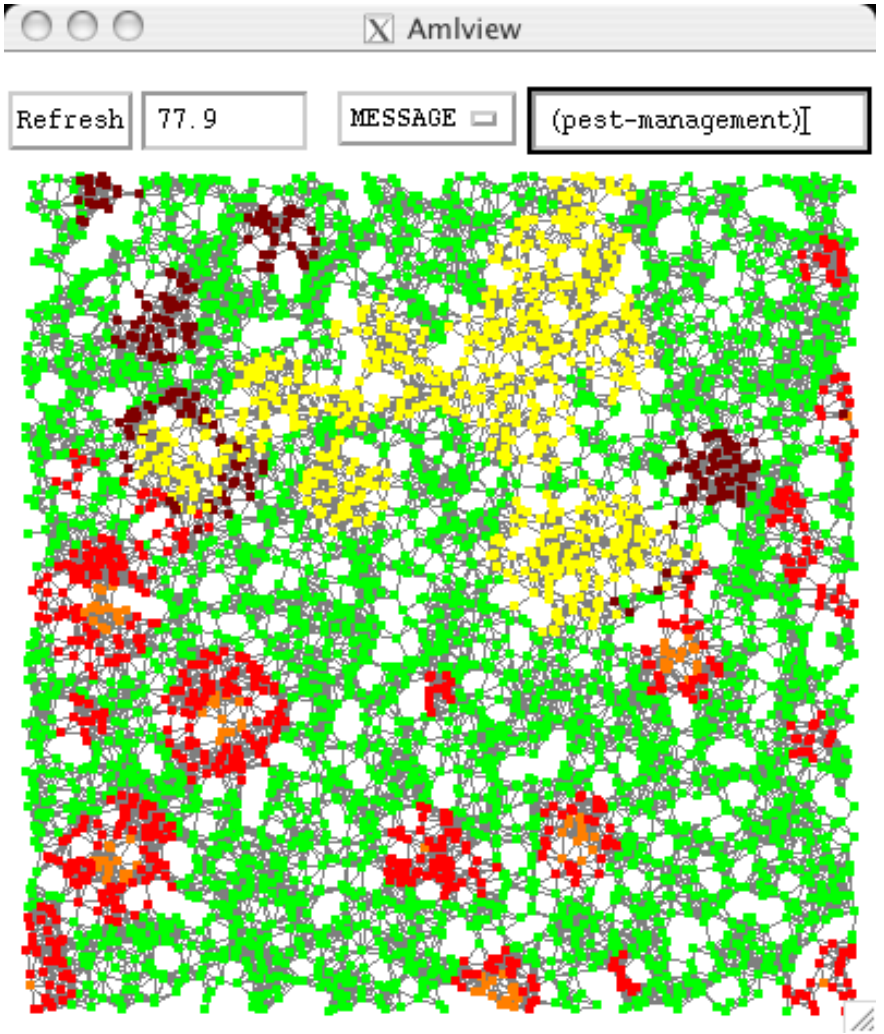
- Persistent Node (Beal, 2003)



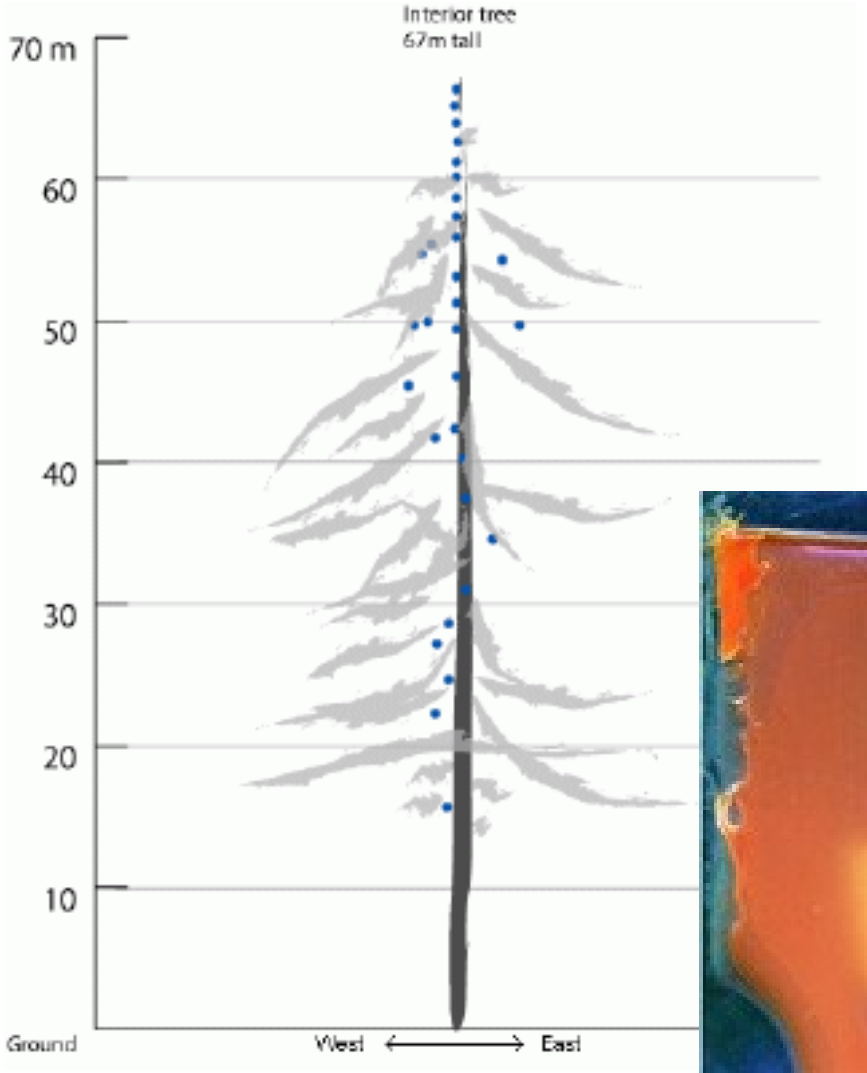
Engineering

- Amorphous Medium & AML (Beal, 2004)





Spatial Computing

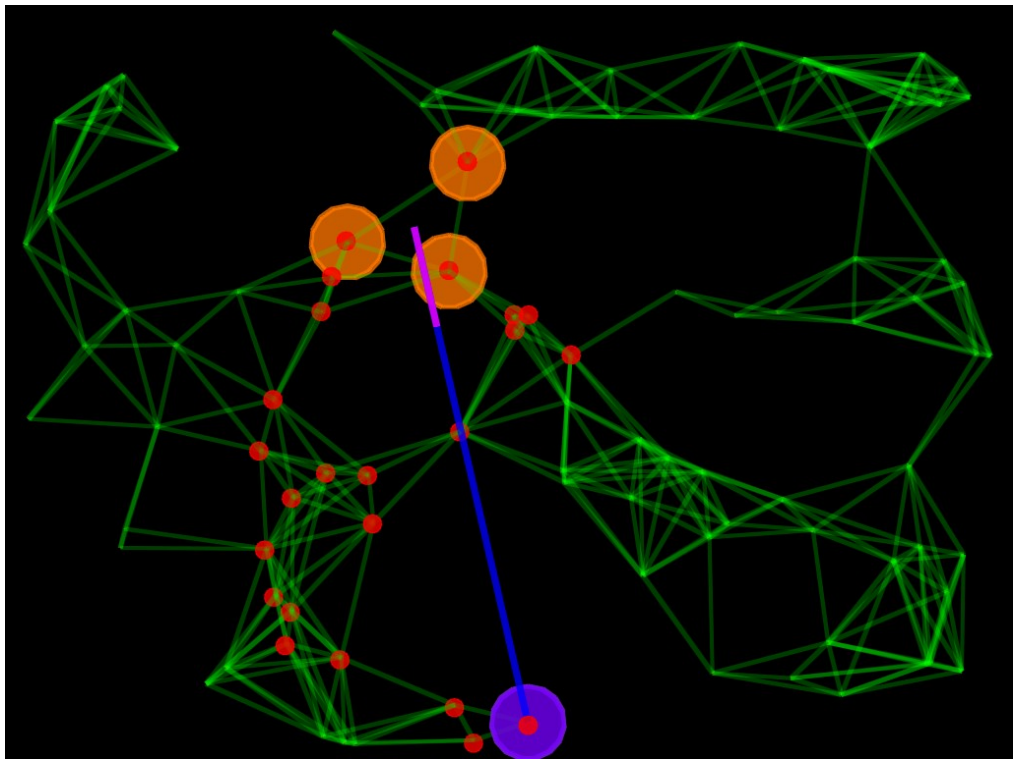


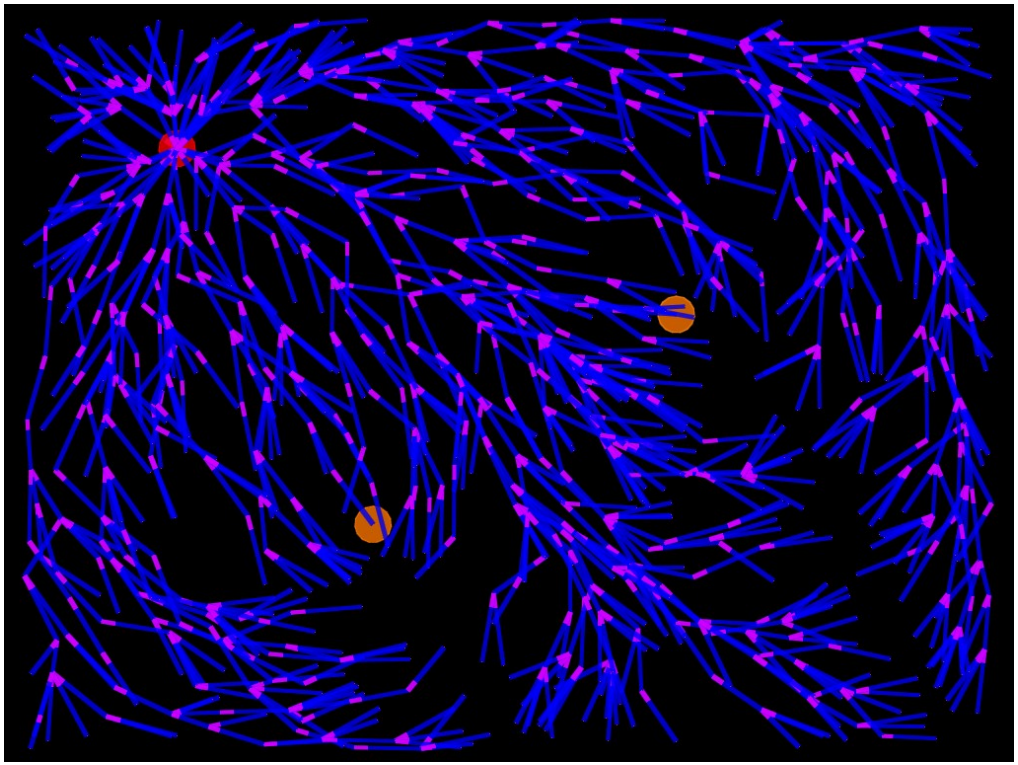
Engineering

- Proto (Beal & Bachrach, 2006)
  - Based on Amorphous Medium
  - 3 sets of space/time primitives:
    - Restriction
    - Incremental evolution
    - Field/summary operations
  - Powerful:
    - Compact code
    - Gradual degradation
    - Automatic scaling

Compact Code

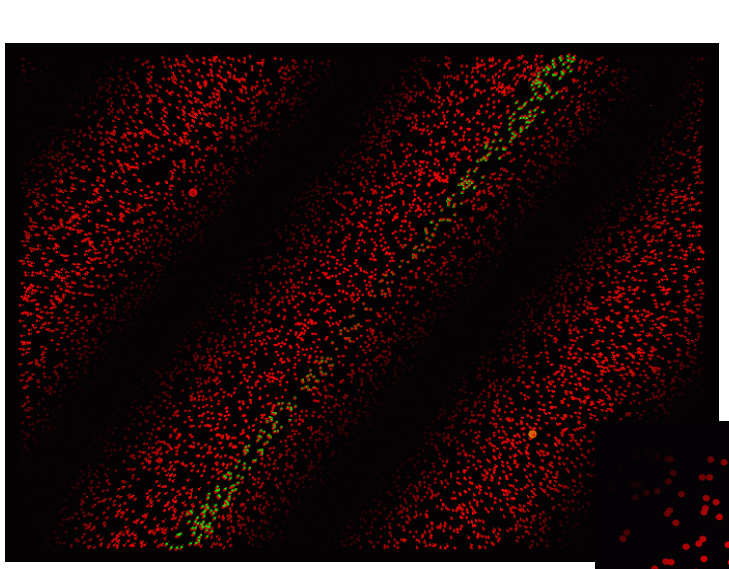
- Target tracking: 28 lines
- Threat avoidance: 22 lines





Gradual Degradation

- Plane wave at different resolutions:



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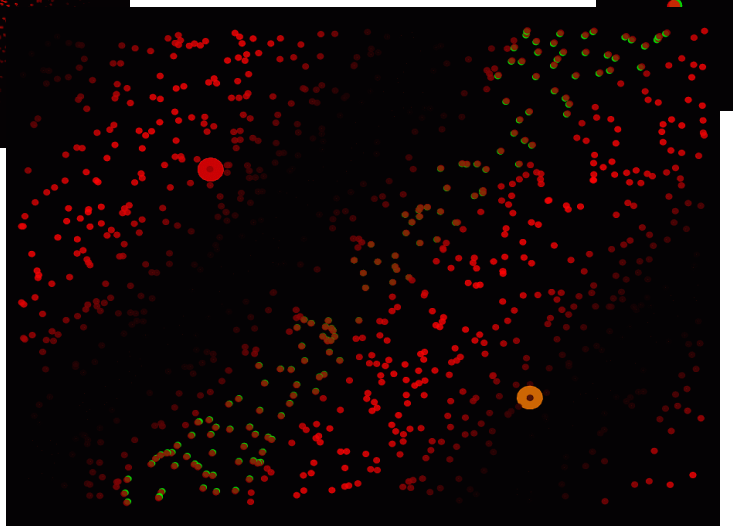

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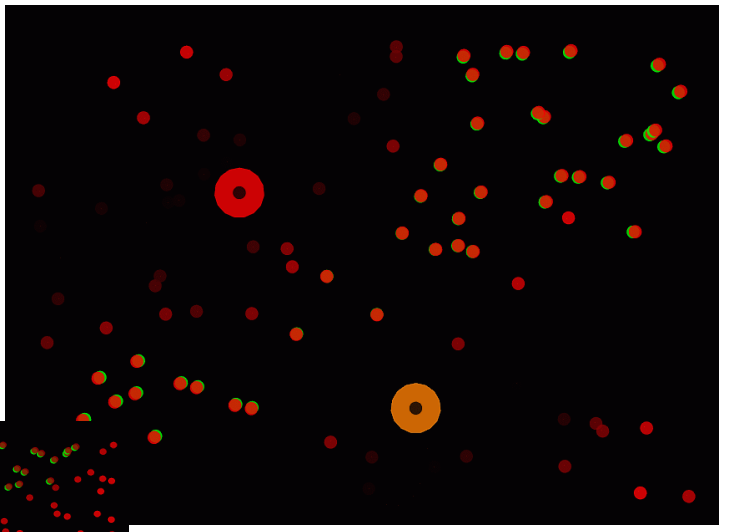

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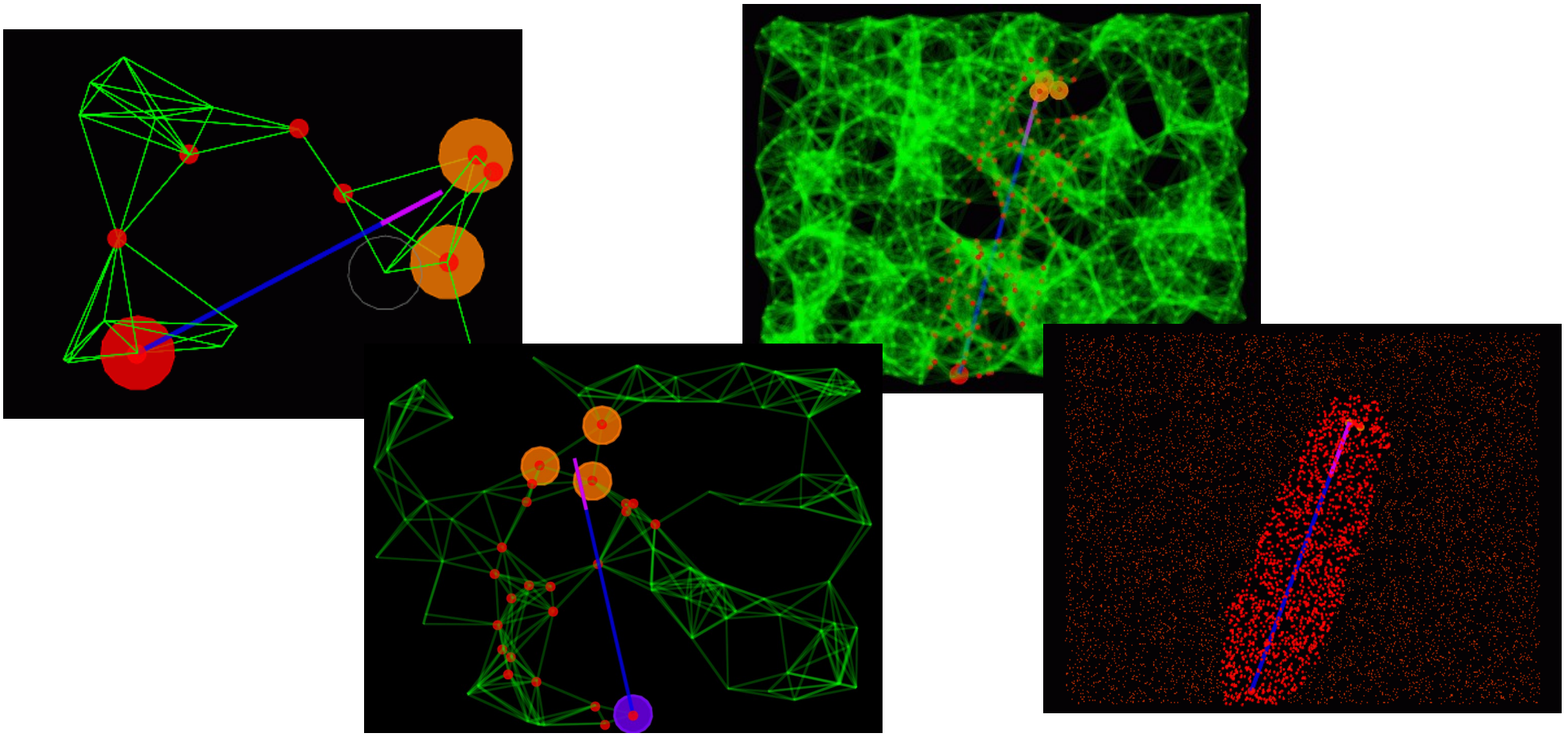
Automatic Scaling

- Target tracking on 20 to 10,000 nodes:



Where now?

- Applications!
  - Swarm robotics
  - Reconfigurable robotics
  - Synthetic biology
  - Sensor networks
- Theory
  - How good are the approximations?
  - How do you predict composition?
  - How do you describe acceptable behavior?