

# From Agents to Multi-Agent Systems:

*Innovation - Application - Science*

Les Gasser

Graduate School of Library and Information Science  
University of Illinois at Urbana-Champaign

[gasser@uiuc.edu](mailto:gasser@uiuc.edu)  
[www.uiuc.edu/~gasser](http://www.uiuc.edu/~gasser)

# Imagine.....

*An operational electric power distribution system uses interacting, coordinated software agents to manage network diagnosis, load balancing, and recovery.*

*--[Spanish electric power utility Iberdrola, in the European Archon Project]*

---

*An electronic library organizes access to online materials with a “service market society” of agents, managing hundreds of users.*

*--[University of Michigan Digital Library Project]*

---

*“Shop-bots” locate products, compare prices, negotiate deals, and represent users in online auctions*

*--[daily occurrence, BestBookBuys, E-Bay, etc.]*

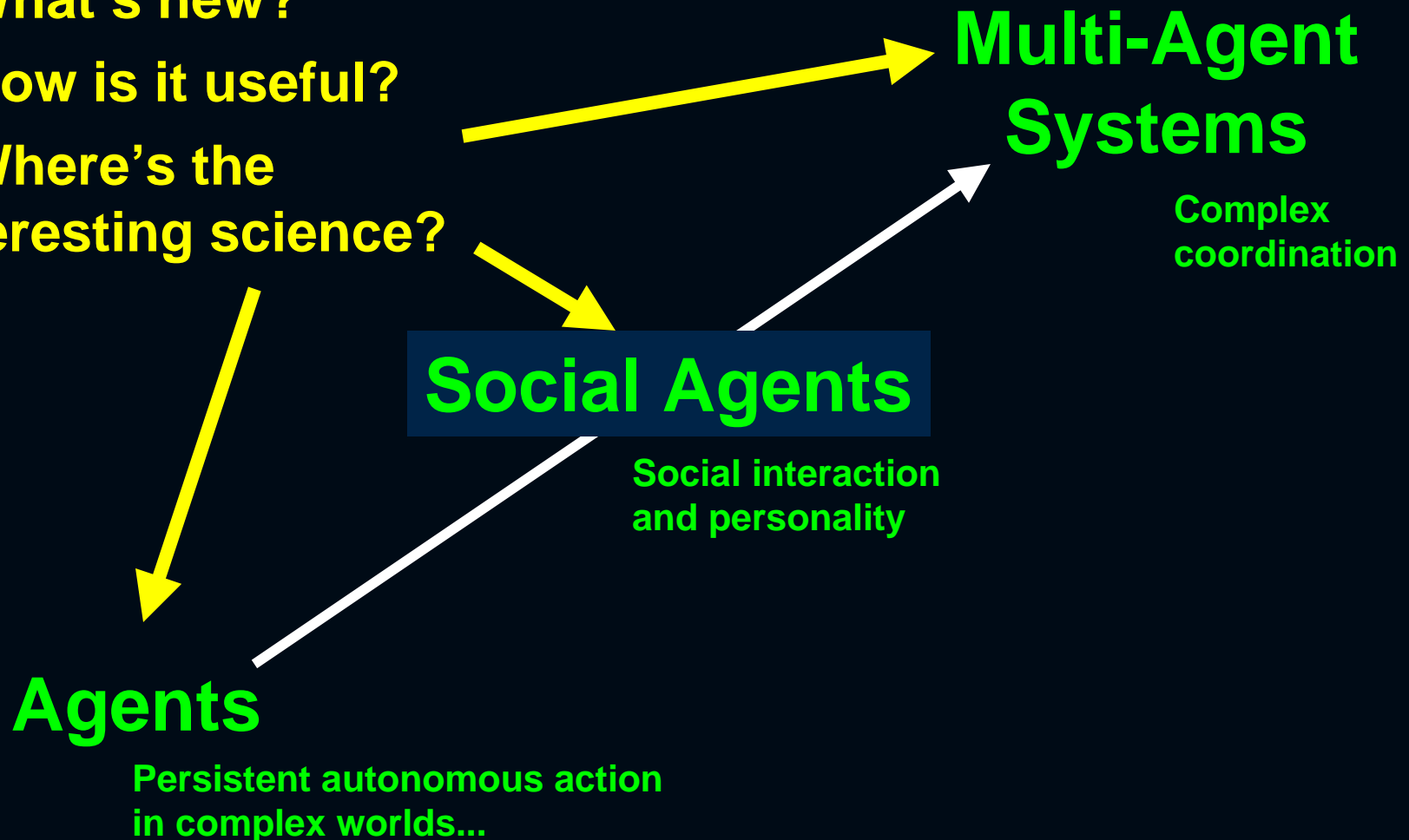
---

*A robot soccer team beats a human soccer team on a regulation field in a regulation game.*

*--[stated goal of the RoboCup Initiative]*

# From Agents to Multi-Agents

- What's new?
- How is it useful?
- Where's the interesting science?



# *Punchlines.....*

- **What's new?**

*Autonomous agency*  
*Interaction & sociability*  
*Collaboration & coordination*

*..automated,  
as infrastructures*

- **How is it useful?**

*Education, e-commerce, entertainment,  
manufacturing, exploration, research, culture,.....*

- **Where's the interesting science?**

*Dynamics and adaptation of agents/multi-agents  
for robustness and scalability*

*Revolution in*



*Scale*

*Complexity*

*Cost*

*Computing*



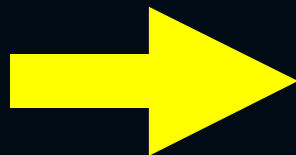
*Connectivity*



*Content*



***Ubiquitous, critical info environment as:***

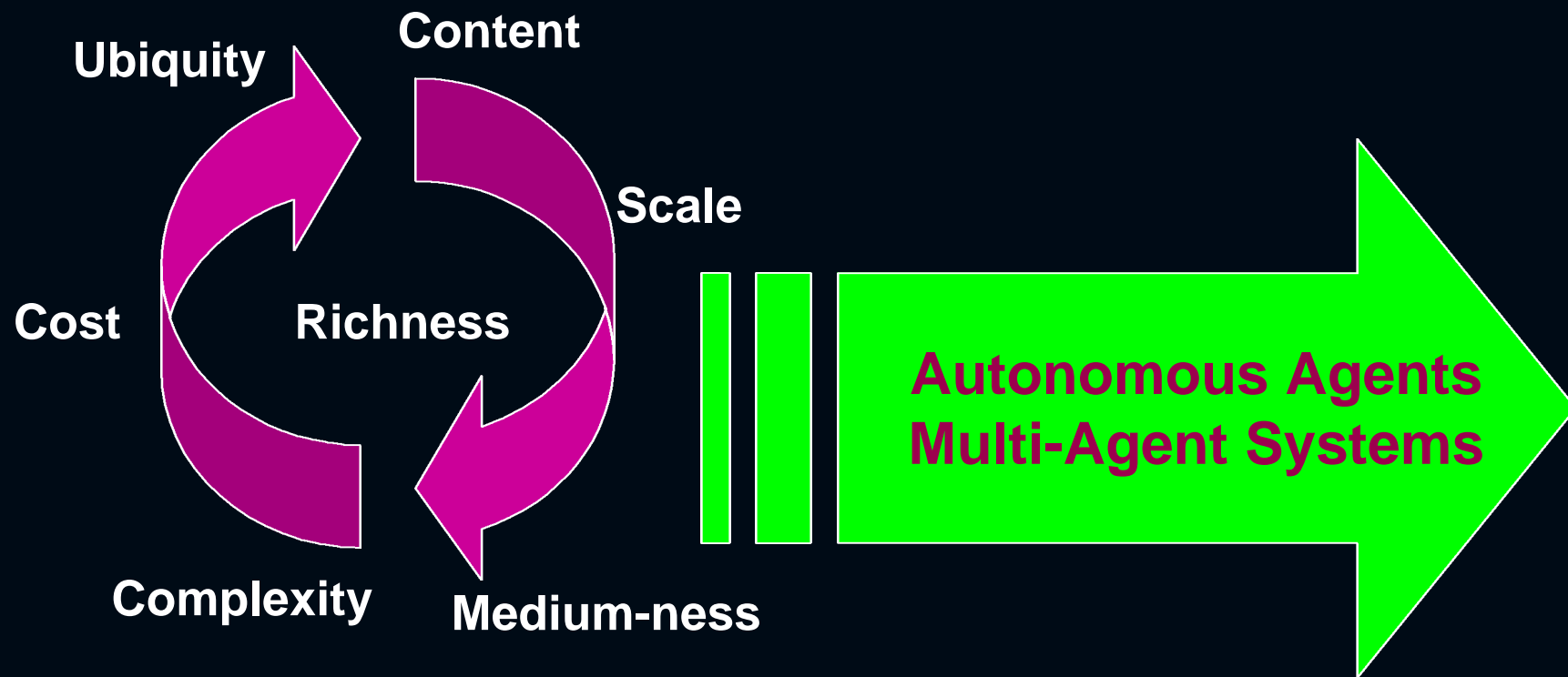


***Technology (direct effects)***

***Infrastructure (hidden, enabling, common)***

***Medium (channel of interaction)***

# It's a fertile environment for emergence of the new....



# Agents: What's new?

## A new paradigm for computing & interaction

Act independently: Be autonomous

Fit with the environment: Exploit conventions

Make informed decisions: Be knowledgeable

Handle diversity: Be broad & flexible

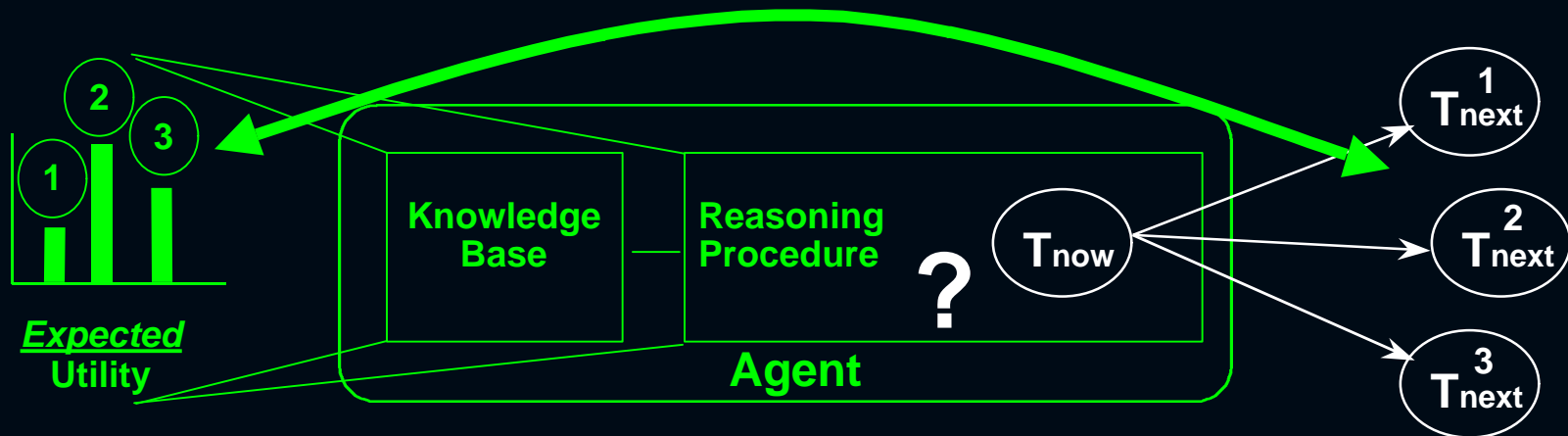
Don't fail: Exhibit persistence & continuity

Adapt to change: Reorganize and learn

Build these capabilities into infrastructure!

# Agents: What's new?

- **Generic, multifunction software architectures** provide **breadth and flexibility**
- **Embedded world knowledge** provides **deep problem-solving capability**
- **Search-based control** provides **structured persistent action:**



➔ The innovation is: all this in a pre-fab package

# Agents: How are they useful?

If we can create self-contained, knowledgeable, persistent agents reliably and cost-effectively, we can hopefully:

- Make higher-level activities routine and automate them
- Manage large information collections modularly
- Integrate legacy systems more easily
- Adapt I.T. to changing requirements without rebuilding
- Package active knowledge for delivery and interaction
  - Education
  - Training
  - Documentation
  - Simulation

(cf. The “Educational Object Economy”)

# Agents: Where's the interesting science?

- *Adaptivity and learning*
- *Representation* (world knowledge, common sense)
- *Continuously-operating systems*
- *Mobility and security*
- *Legal and social issues.*

# Social Agents: What's new?

*To be productive in a social world, agents need to:*

- *Interact with others (people & agents)*
- *Engage others over time (people & agents)*

# Social Agents: What's new?

## *Social Agents can:*

- ***Communicate***
  - *Using specialized “agent communication languages”*
  - *Using natural language and behavior*
- ***Engage others over time*** (people & agents)
  - *Through predictable, consistent behavior*
  - *Through personality and emotion*
- ***Trust and be trusted*** ([by] people & agents)
  - *Trust as compiled experience for risk management*

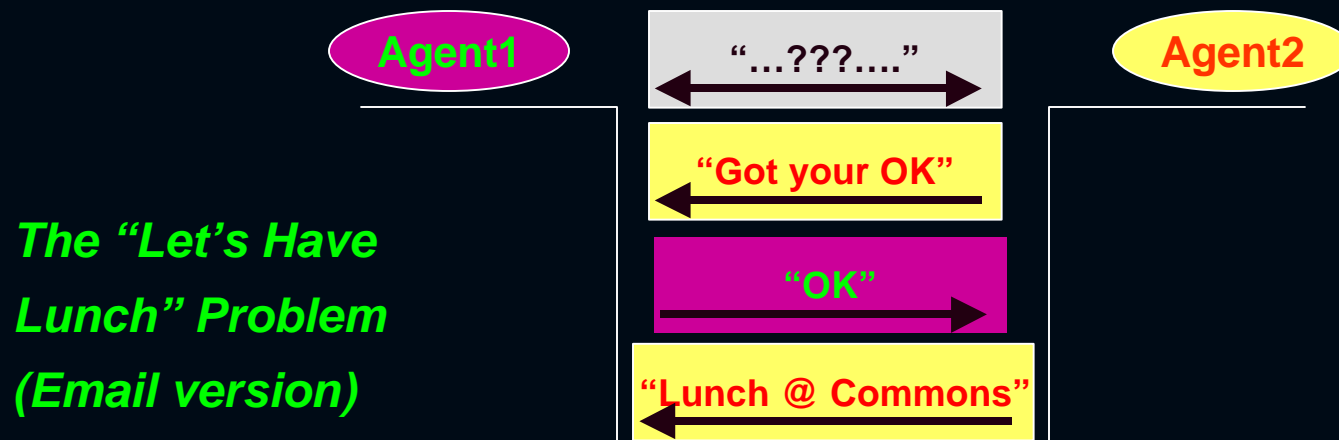
# Social Agents: How are they useful?

- **Agent-based childrens' story/theater environments** [*Barbara Hayes-Roth's work; [extempo.com](http://extempo.com)*]
- **Ananova news-reading agent** [[www.ananova.com](http://www.ananova.com)]
- **Agent-based pedagogy** [*Center for Research in Agent-based Training Environments (CRATE) at ISI*]
- **B2B E-Commerce** [*FIPA: Foundation for Intelligent Physical Agents ([www.fipa.org](http://www.fipa.org)) ACL Standards* ]

# Social Agents: Where's the interesting science?

## Understanding communication

*What communication rules will assure correct understanding and reliable joint activity?  
(This is the dominant view of the main issue...)*



# A Midsummer Night's Dream

**Moon:** This lantern doth the horned moon present;  
Myself the man i' the moon do seem to be.

.....

**Thes:** This is the greatest error of all the rest: the man  
should be put into the lantern. How else is the  
man i' the moon?

.....

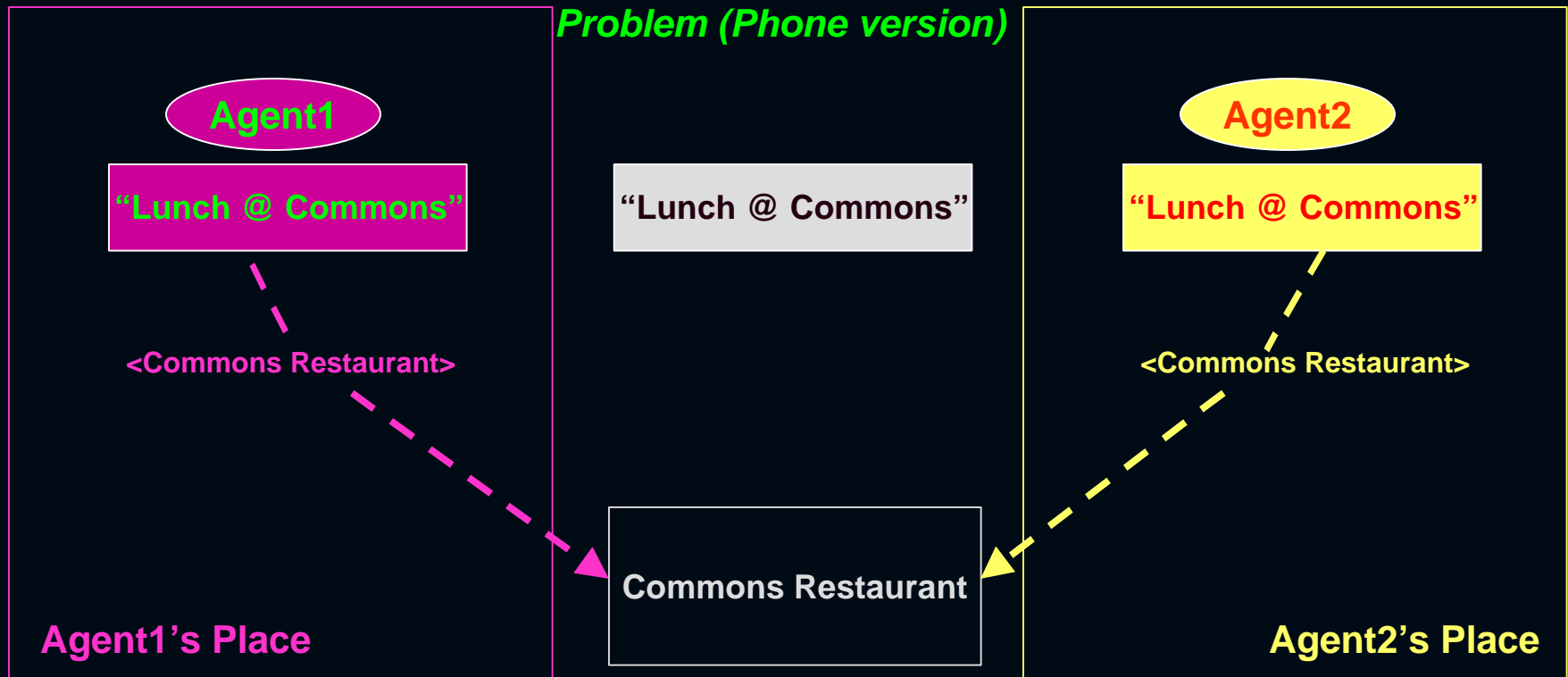
**Moon:** All that I have to say, is, to tell you that the  
lantern is the moon;  
I, the man in the moon;  
This thornbush, my thornbush;  
And this dog, my dog!

# Social Agents: Where's the interesting science?

*Understanding meaning in communication*

*What communication rules will assure correct understanding and reliable joint activity?*

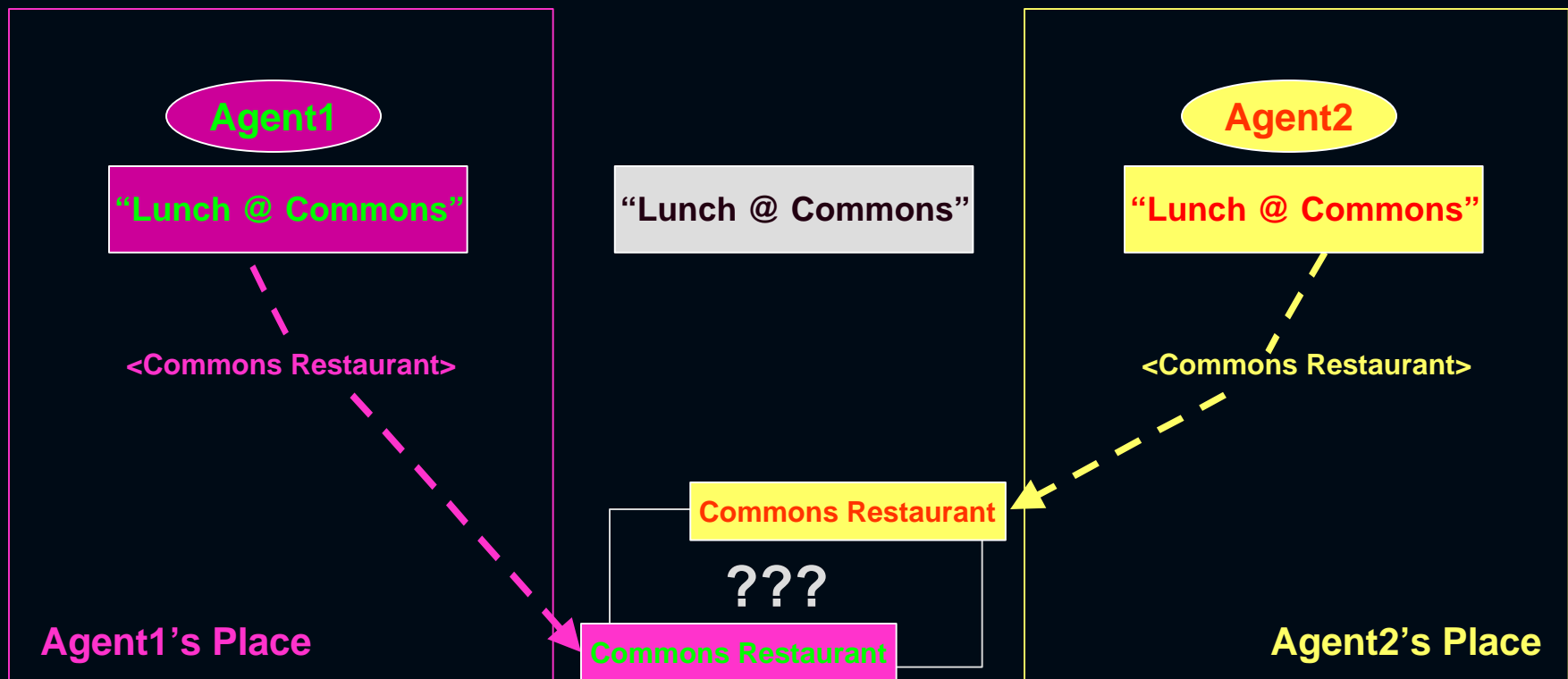
*The "Let's Have Lunch"  
Problem (Phone version)*



# Social Agents: Where's the interesting science?

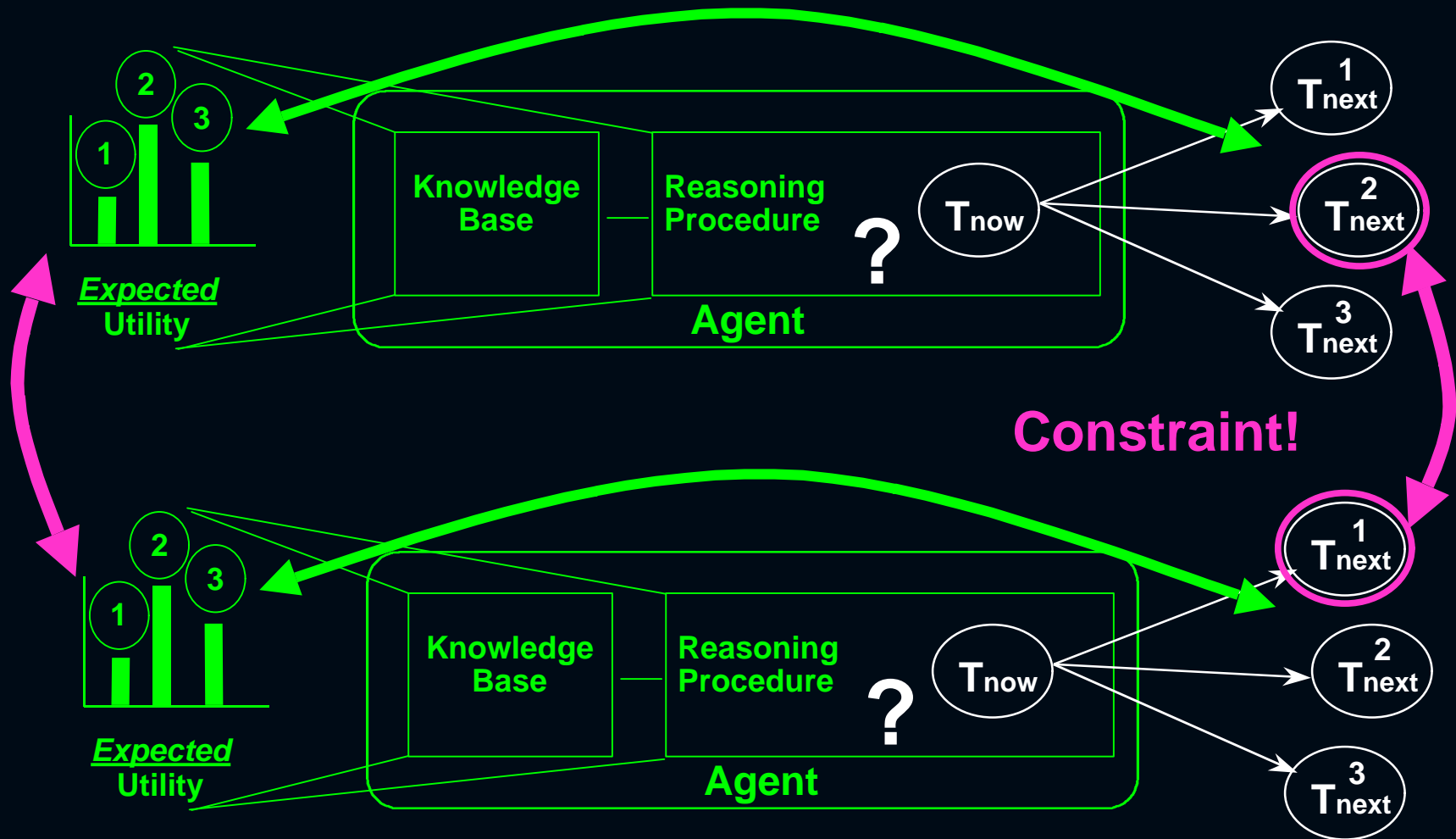
## Understanding meaning in communication

The "Let's Have Lunch" Problem (Phone version)



# Multi-Agents: What's new?

## Coordination



# Multi-Agents: How are they useful?

*In environments where there is:*

- *Natural division of labor*
  - *Specialization*
  - *Localization*
  - *Arms-length relationships*
- *Need for coordination* (due to interdependencies)
- *Adequate knowledge for control & recovery*

# Recall....

*An operational electric power distribution system uses interacting, coordinated software agents to manage network diagnosis, load balancing, and recovery.*

*--[Spanish electric power utility Iberdrola, in the European Archon Project]*

---

*An electronic library organizes access to online materials with a “service market society” of agents, managing hundreds of users.*

*--[University of Michigan Digital Library Project]*

---

*A robot soccer team beats a human soccer team on a regulation field in a regulation game.*

*--[stated goal of the RoboCup Initiative]*

---

*Intelligent home automation (with technologies like JINI)*

*Space exploration (with 1000's of microrobots)*

*Gaming (with multi-agent-based interactive games)*

*Manufacturing and network control*

*Sensor nets.....*

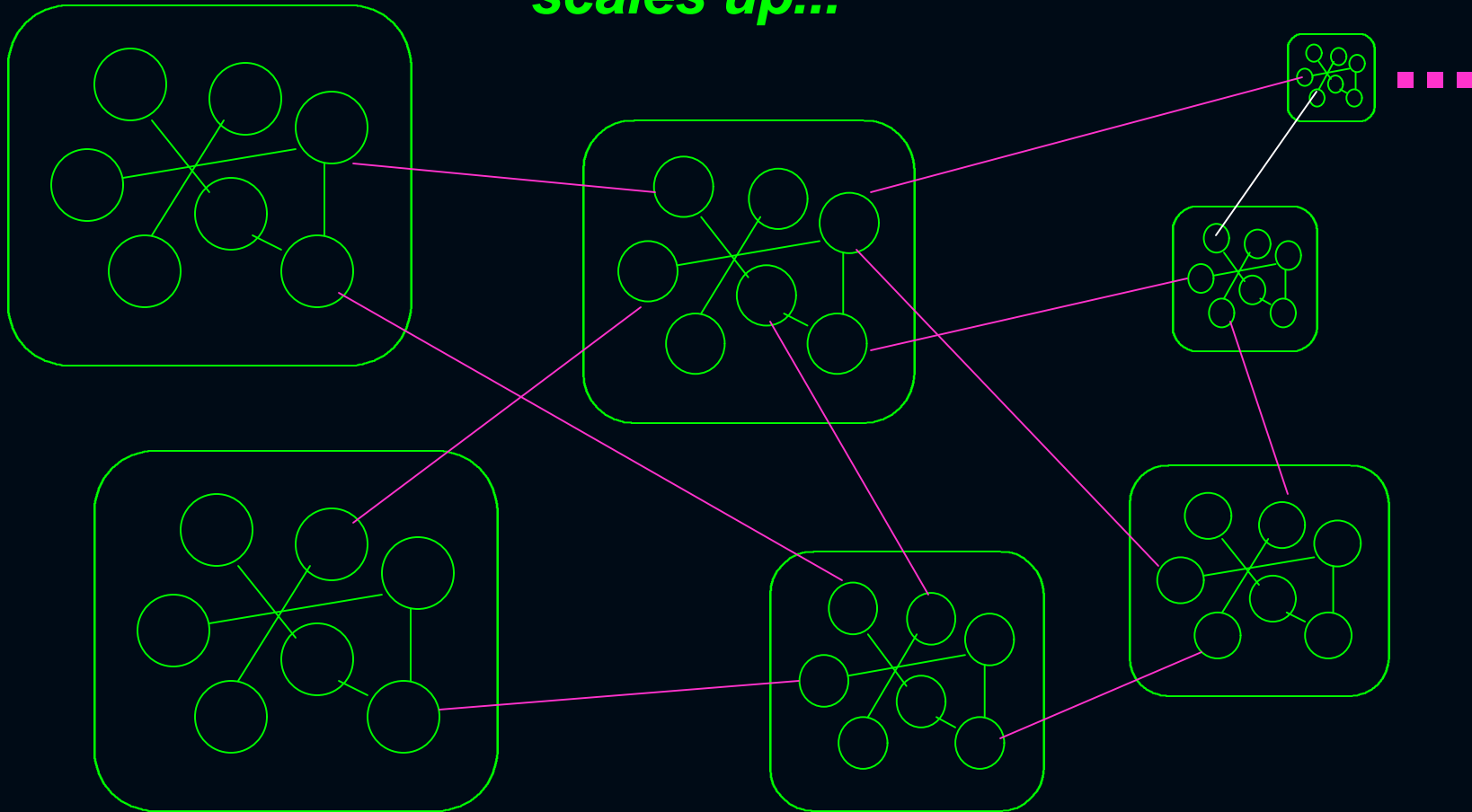
# Multi-Agents: Where's the interesting science?

*Major challenges include*

- *Scaling coordination  
to 100s-1,000,000s*
- *Language evolution*

# Multi-Agents: Where's the interesting science?

*The coordination problem scales up...*



*Suppose these are language constraints!*

# **XML.ORG's Catalog of XML Standards for Electronic Commerce (One of about a hundred categories)**

**CommerceNet eCo Framework**

**Commerce One Common Business Library (CBL)**

**CXML.org Commerce XML (cXML)**

**Electronic Business XML Initiative (ebXML)**

**Environmental Research Institute of Michigan (ERIM) Center for E-Commerce**

**IBM: Business Rules Markup Language (BRML)**

**Trading Partner Agreement Markup Language (tpaML)**

**Joint Electronic Commerce Program Office (JECPO)**

**Product Data Markup Language (PDML)**

**Open Trading Protocol (OTP)**

**Science Applications International Corporation (SAIC)**

**Universal Commerce Language and Protocol (UCLP)**

**Visa XML Invoice Specification**

**Open Applications Group, Inc (OAG)**

**BikeXML.org**

**XBRL**

**SeeBeyond**

**eKeeper.com (EXBRL)**

**Edifecs SpecBuilder**

**CommerceDesk**

**Electronic Commerce Workshop Datatyping for Electronic Data Interchange**

**SourceTrack Marketplace XML (mpXML)**

# Language Evolution

- *Many experiments have agents forming collective lexicons autonomously*
- *Early experiments have agents forming rudimentary grammars and syntax*
- *Early analyses begin so capture the limits and possibilities of convergence on common languages*
- *Languages and grammars are good metaphors and foundations for many kinds of information systems (websites, libraries, organizations)*

# Conclusions

**“May you live in interesting times!”**

**.....We do!**