Strategic Actors Modeling for Requirements Engineering - the i* framework

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Tutorial presented at the One-Day Symposium
"Modelling Your System Goals – The i* Approach"
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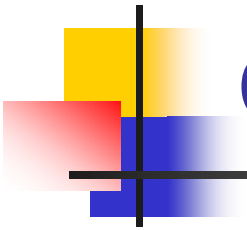
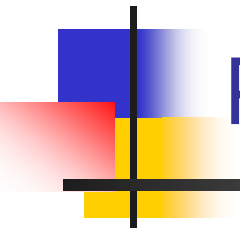
British Computer Society – Requirements Engineering Specialist Group



Outline

1. Why Early RE
2. What modelling to support Early RE
3. i* modelling constructs
   - Examples
4. Exercise
5. AO modeling principles
6. Ongoing work



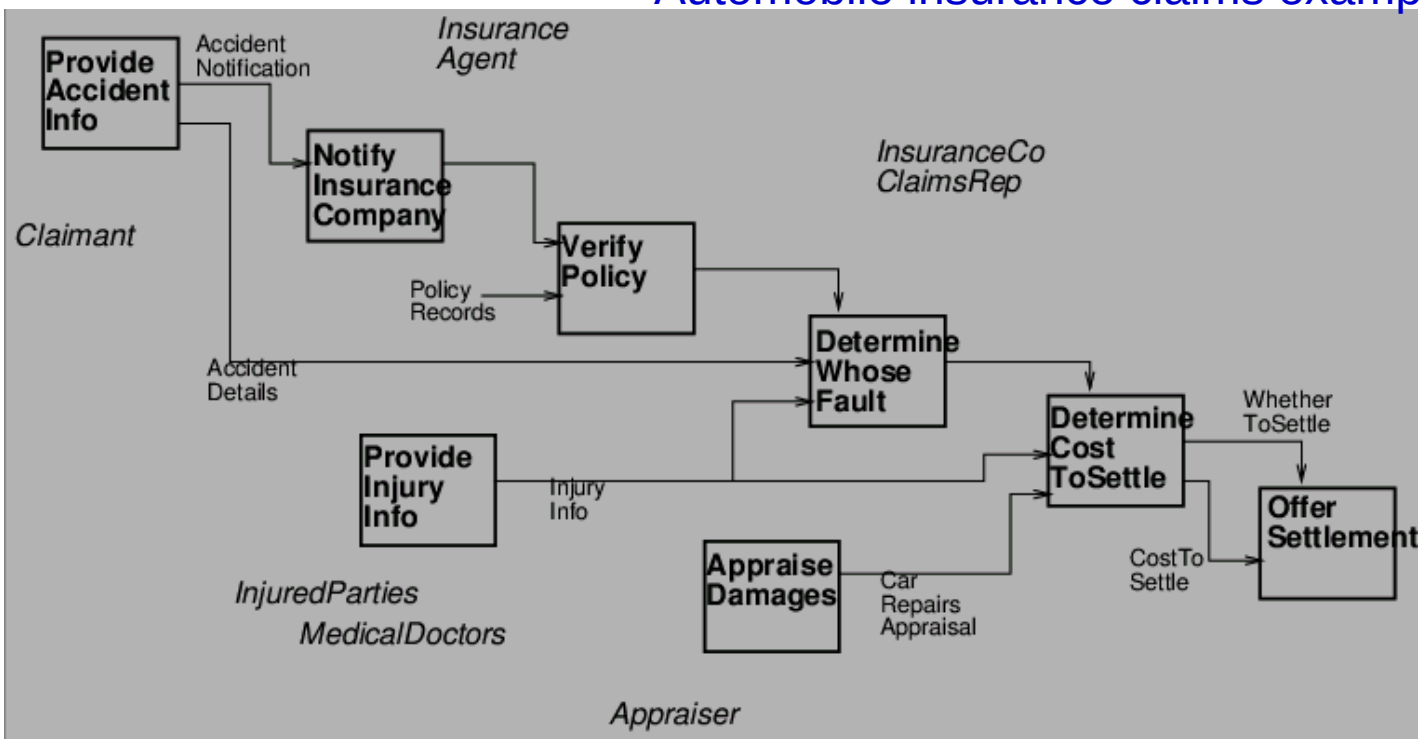
Part 1 - Why Early RE

- What is Early RE?
- Why Early RE?
- Why Early RE now?

What is Early RE?

- Cf traditional requirements modelling

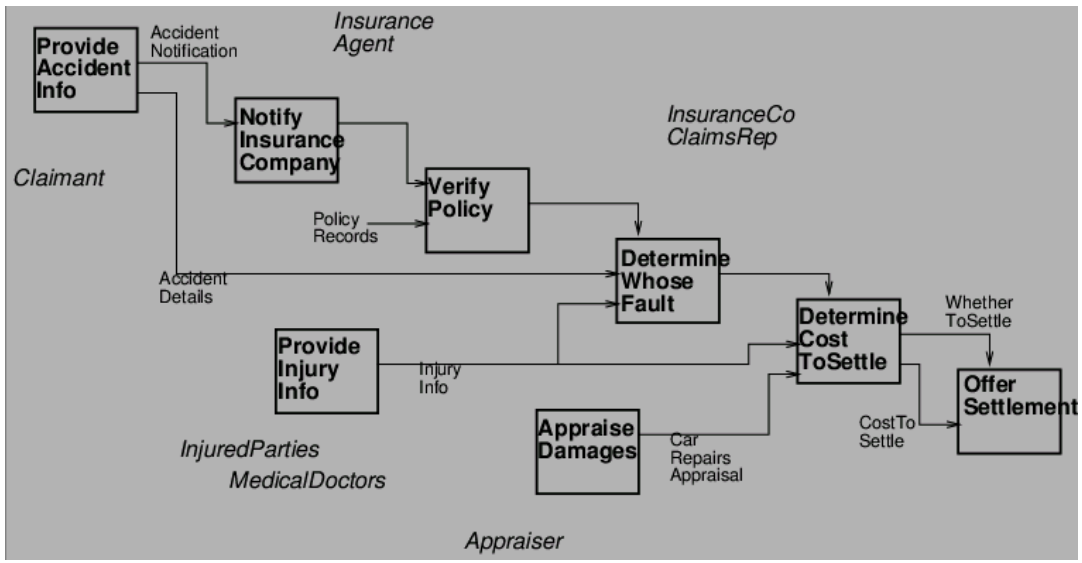
Automobile insurance claims example

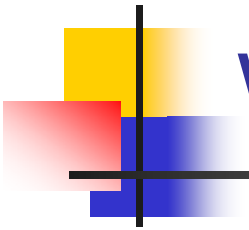


... but we need deeper understanding!

… a deeper understanding about processes

- Car owner wants car to be repaired
- Insurance company wants to minimize claims payout
- Car owner wants fair appraisal of repairs
- Insurance agent wants to maintain good customer relations

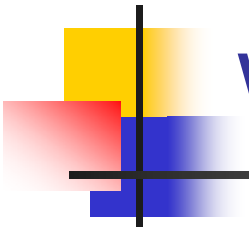




Why is Early RE important?

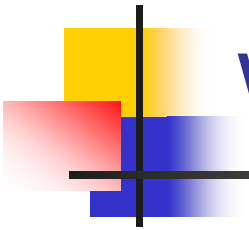
- What do you need to be concerned about?
  - Solving the wrong problem
  - Socio-technical system failure, disuse
  - Changing needs
  - Globalization, internationalization
  - Changing regulations

- Consider a health care system ...



Why is Early RE important now?

- World more connected, more networked
- Stakeholder powers, disparate interests
- World more dynamic, structural changes
  - Business model changes - IT capabilities changes lead to fundamental changes in business models, industry-wide, leading back to system changes



Why is Early RE important?

- Complex relationships among stakeholders
  - what they want
    - E.g., security, privacy, trust, profitability, market positioning, strategic alliances, intellectual property, ...
  - How they can achieve what they want
- Need systematic method, bring into RE process
  - modelling and reasoning support, tools, traceability, ...
- Before defining the system to be built
- Consider:
  - E-business
  - Transportation
  - E-learning
  - E-government

Nicholas Carr: “IT doesn’t matter”

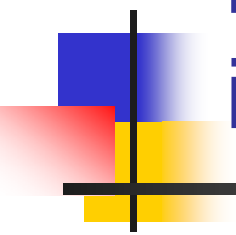
- From 1992 to 2001, US companies spent over $2.7T on hardware, software, and services – IDC
- Research (2002) shows only a random correlation between IT spending per employee and return on shareholder equity – Strassman
- On average, only 7% of software functionality that was paid for is actually used – Gartner
- IT projects often suffer from a prolonged delay to realizing value, an average of 18 to 24 months from initiation to operations (usually only providing a one-time cost impact) – Standish Group (2003)
- 85% of IT projects fail to meet objectives (with 32% being cancelled outright) – Gartner

But does this mean that IT Doesn’t Matter?

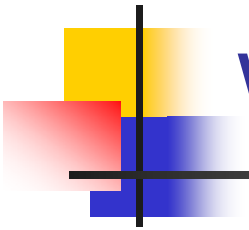
We think not

[Howard Smith, CSC, 2004]

- IT still matters
- ... but it is even more important to know how to use technology wisely
- Requirements engineering - not only to elicit and specify what the user wants, but help explore what is possible, desirable, and viable



Part 2 - What modelling do we need in order to support Early RE?



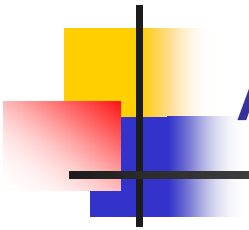
What to look for

- Most systems today exist in complex socio-technical settings
- How do we boil down to small number of modeling constructs?
- What do we look for in
  - Expressiveness
  - Reasoning support

So what are the important concepts for Agent Orientation as a Modelling Paradigm ?

- **Intentionality**
- **Autonomy**
- **Sociality**
- **Identity & Boundaries**
- **Strategic Reflectivity**
- **Rational Self-Interest**

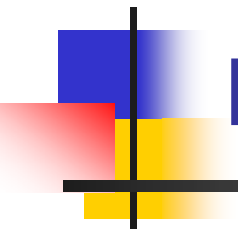
E. Yu. "Agent Orientation as a Modelling Paradigm," Wirtschaftsinformatik, April 2001.



Approach

- Strategic actors modelling
  - To model and analyze complex relationships among actors with strategic intent
    - includes humans and machines

- What i* does not aim to do
  - Execution level analysis
  - Temporal dimension

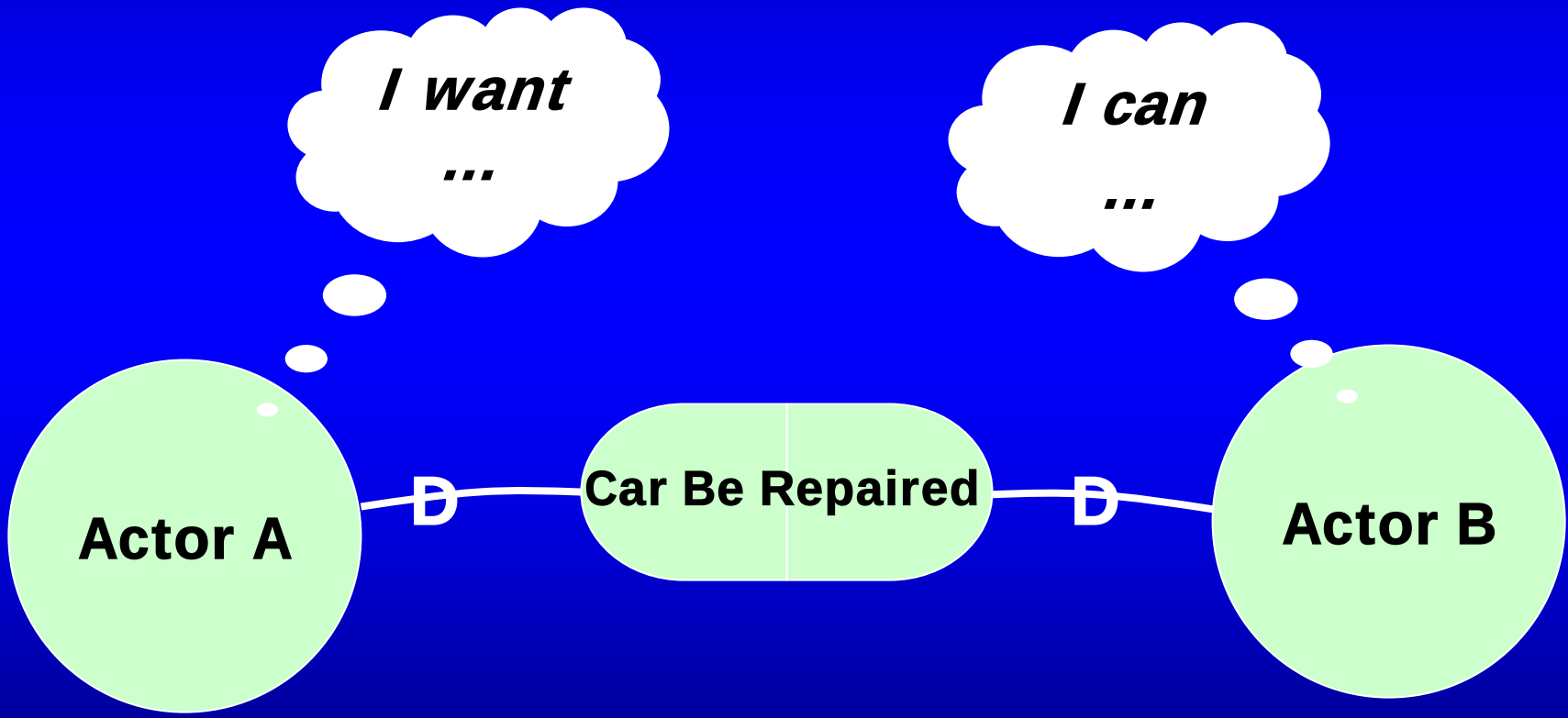


Part 3 - i* modelling constructs

Approach: model social relationships for analysis and design

- Strategic actors
  - What do I want?
  - How can I achieve what I want?
  - Who do I depend on to achieve what I want?

Strategic Dependency Relationship

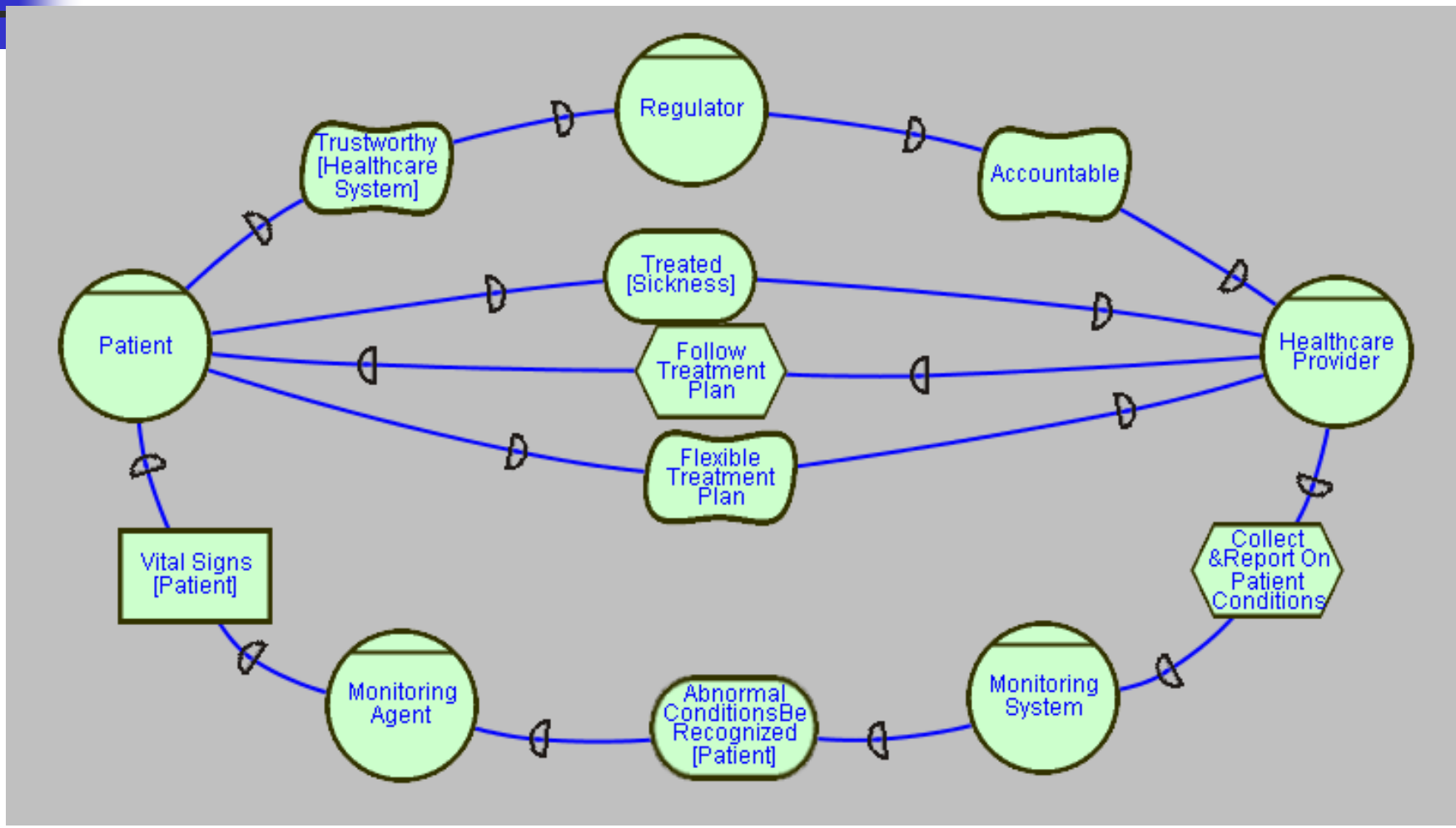


Modelling Strategic Actor Relationships and Rationales

- *the i* modelling framework*

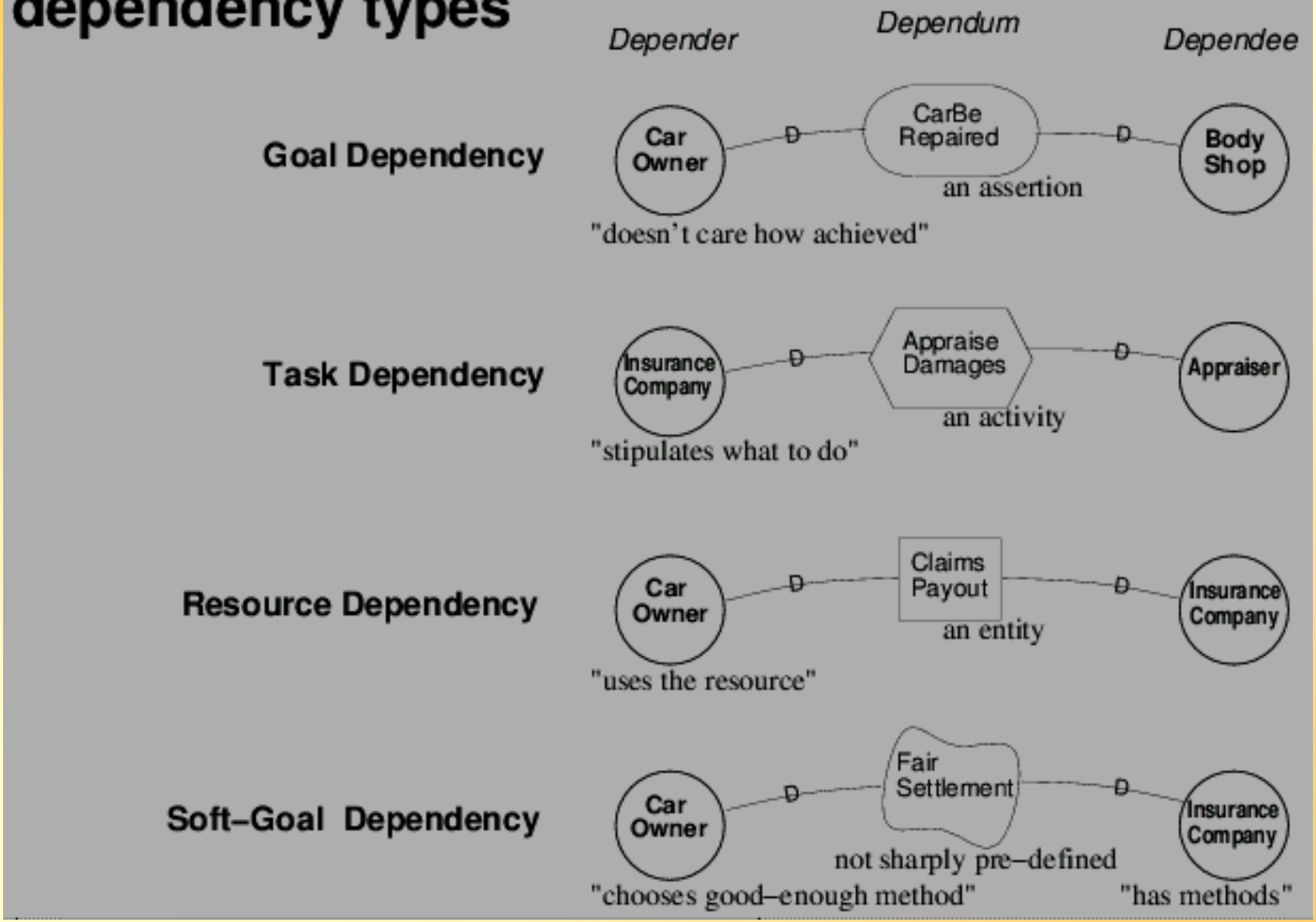
- **Strategic Actors**
  - have goals, beliefs, abilities, commitments
  - are semi-autonomous
    - freedom of action, constrained by relationships with others
    - not fully knowable or controllable
    - has knowledge to guide action, but only partially explicit
  - depend on each other
    - for goals to be achieved, tasks to be performed, resources to be furnished

let's model systems and organizations in terms of Strategic Dependencies among actors



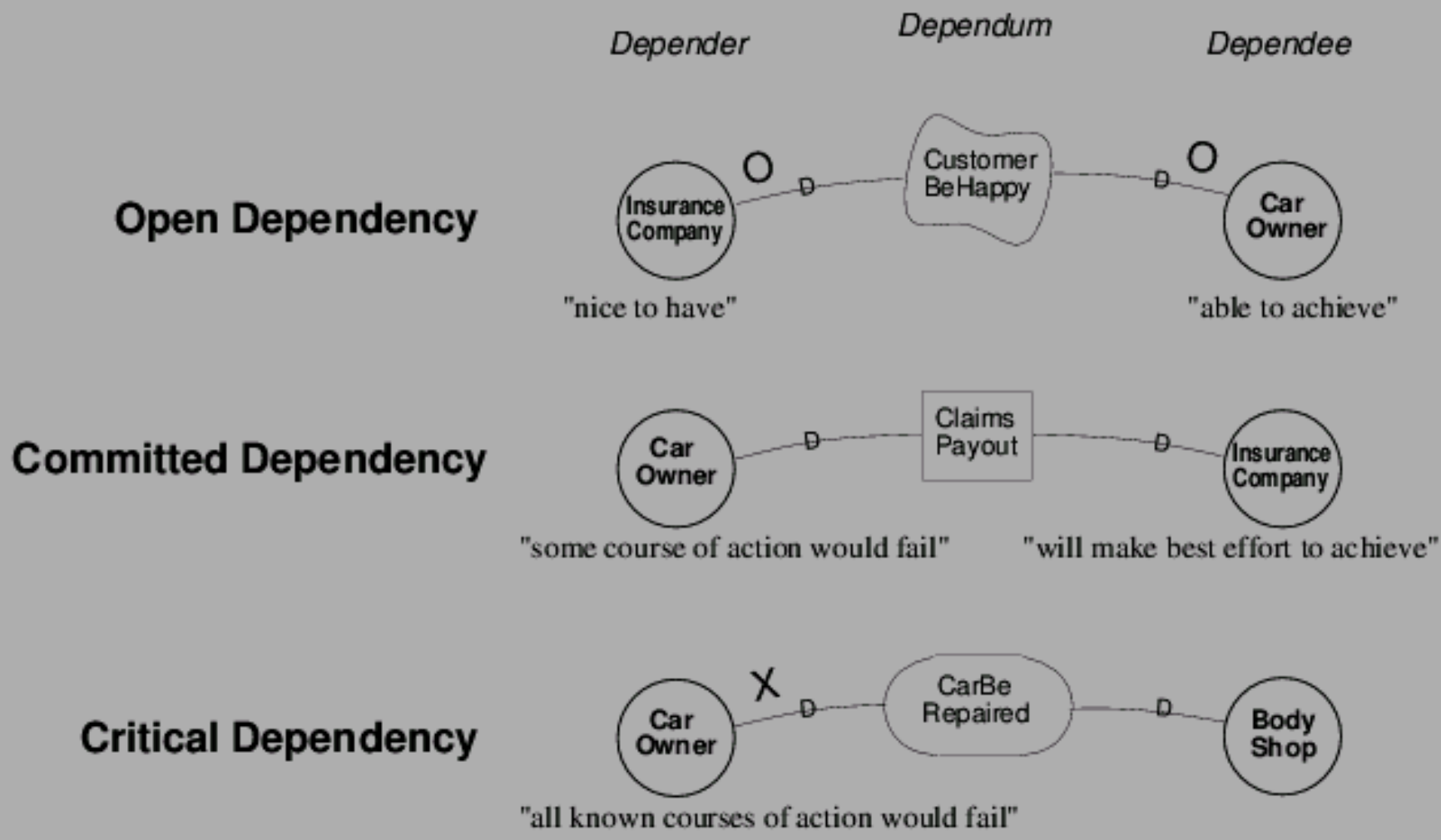
Strategic Dependency Model

dependency types

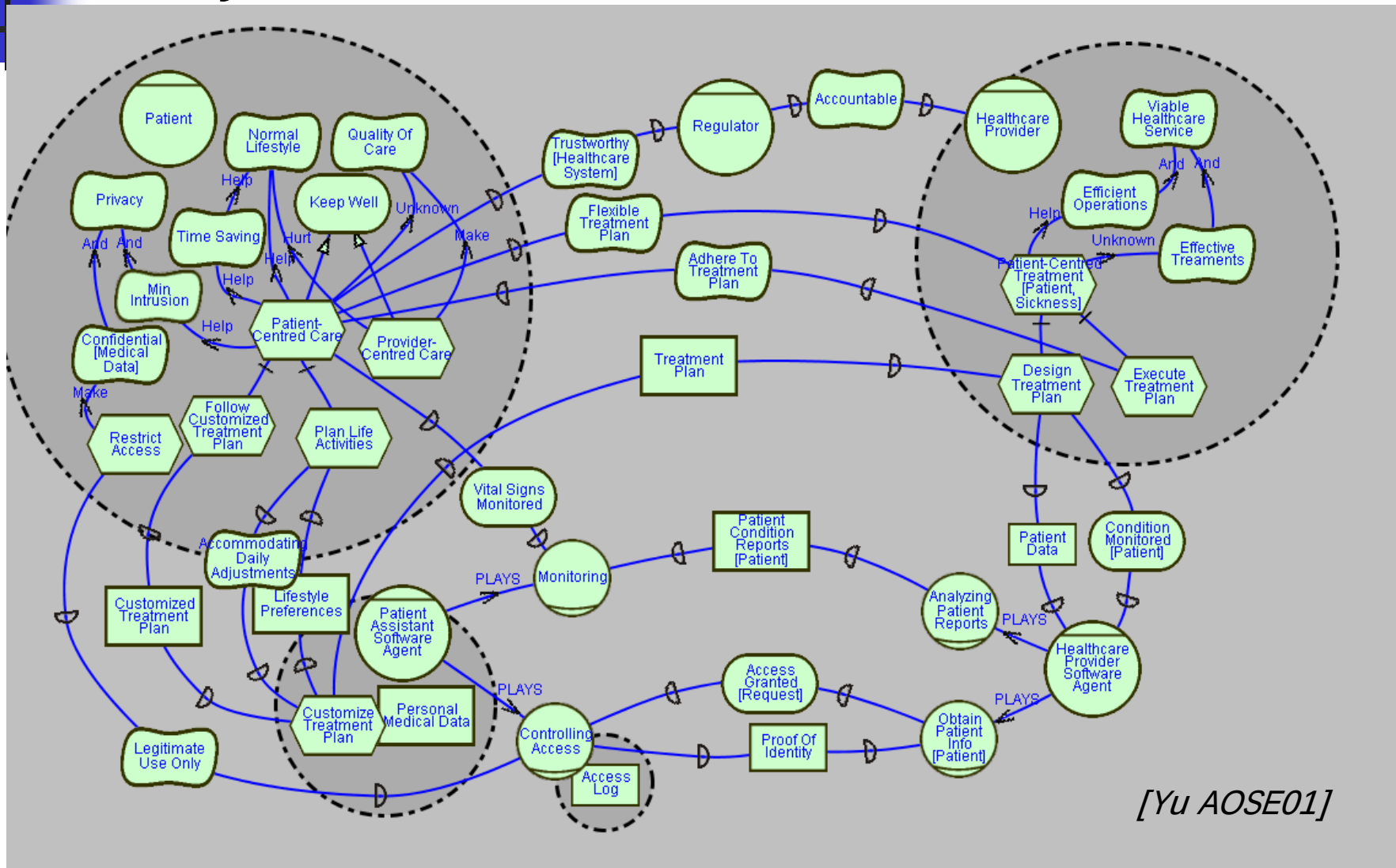


Strategic Dependency Model

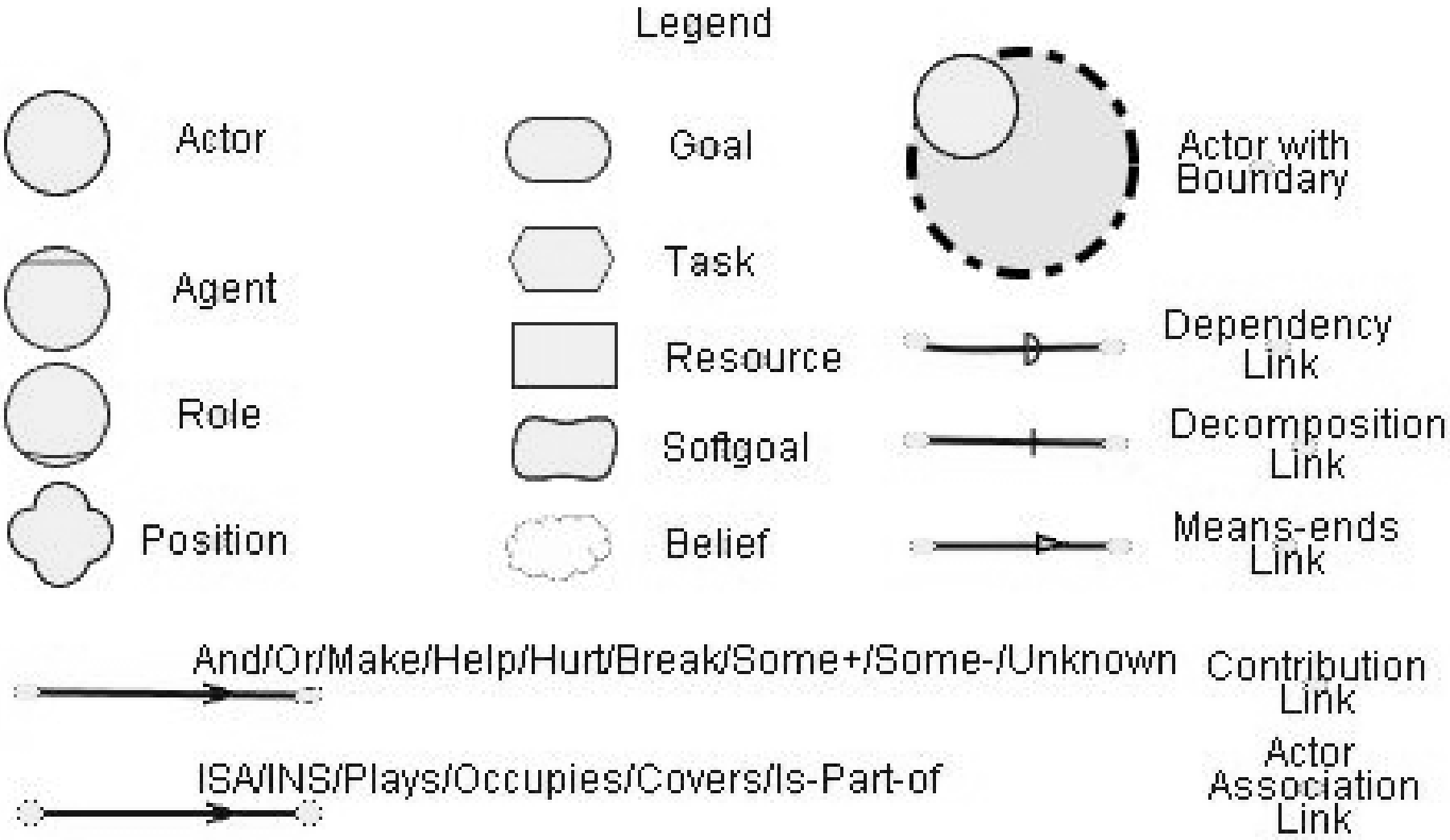
dependency strengths



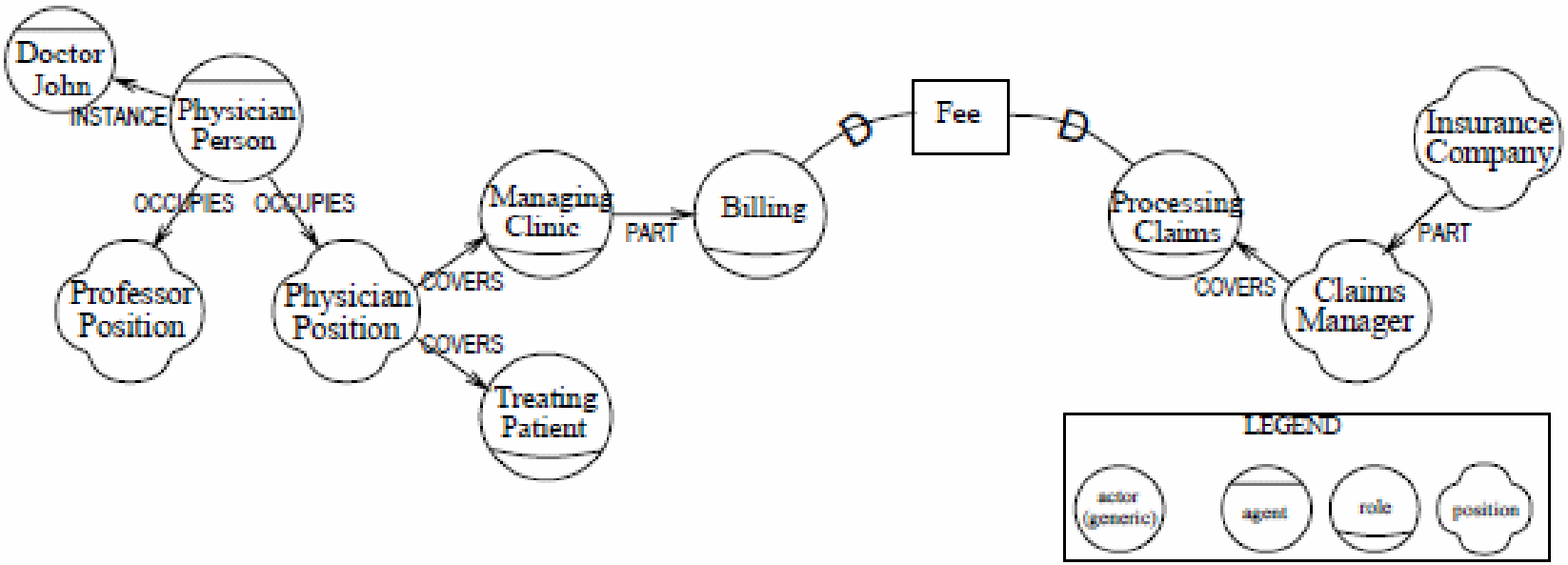
Strategic Rationales about alternative configurations of relationships with other actors – *Why? How? How else?*



[Yu AOSE01]


Legend
Actor
Agent
Role
Position
Goal
Task
Resource
Softgoal
Belief
Actor with Boundary
Dependency Link
Decomposition Link
Means-ends Link
And/Or/Make/Help/Hurt/Break/Some+/Some-/Unknown
Contribution Link
ISA/INS/Plays/Occupies/Covers/Is-Part-of
Actor Association Link

Roles, Agents, Positions



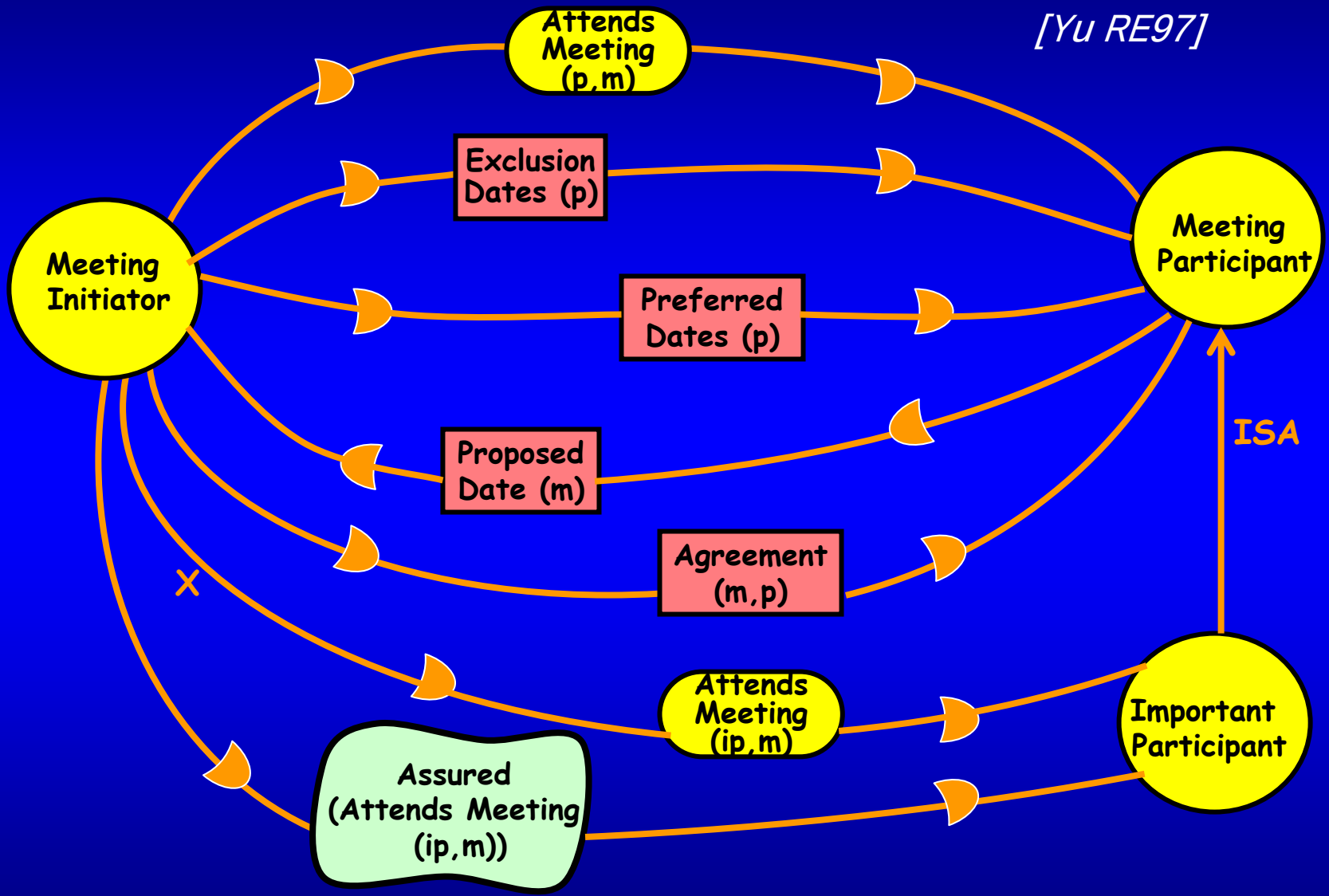
- Role as abstract actor
- Agent as concrete actor
- Position as a set of roles typically assigned to one agent

An Example
Meeting Scheduler

From: E. Yu. Towards Modelling and Reasoning Support for Early-Phase Requirements Engineering

3rd IEEE Int. Symp. on Requirements Engineering (RE'97) Jan. 6-8, 1997, Washington D.C., USA. pp. 226-235.

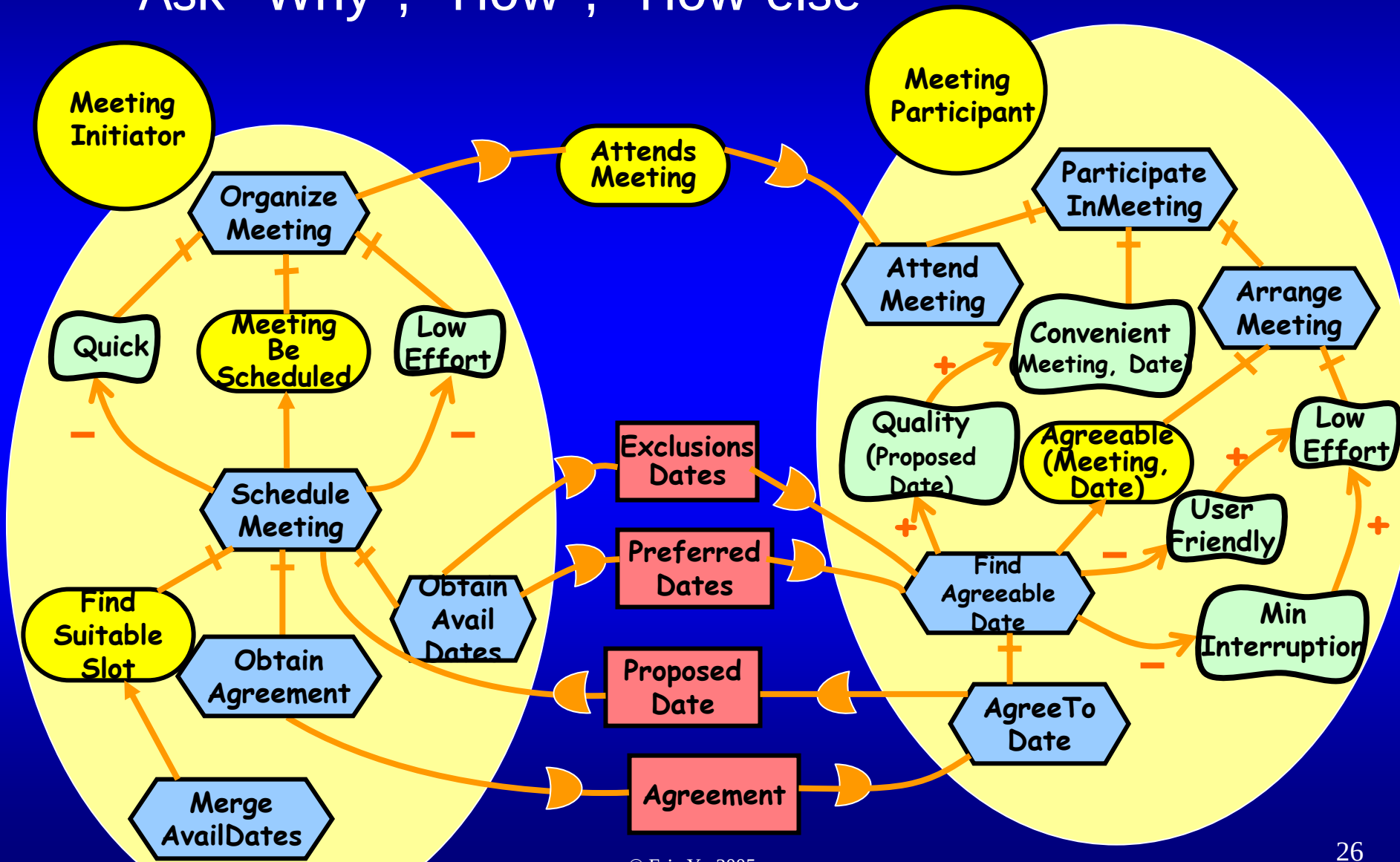
Strategic Dependency (SD) model



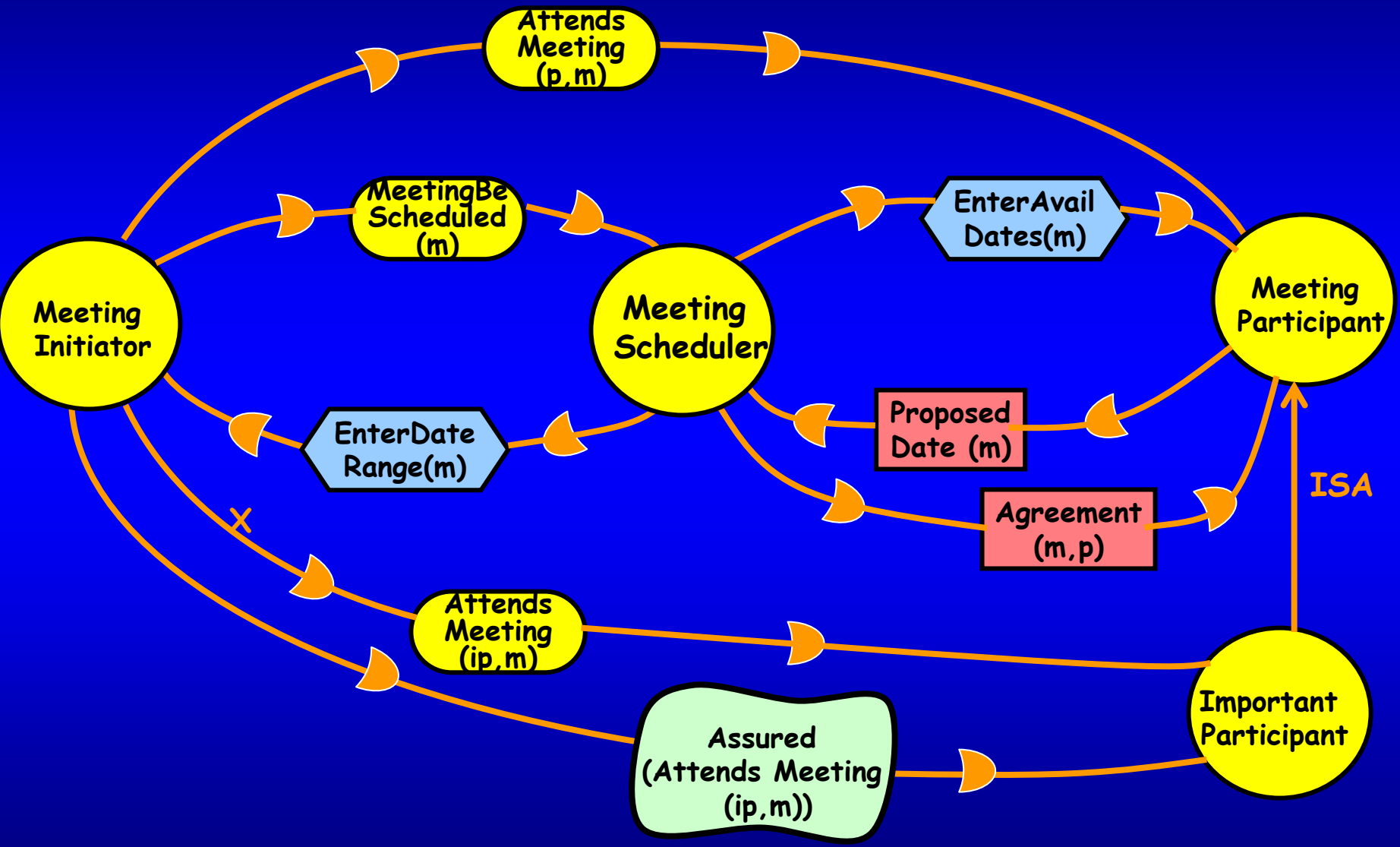
Meeting Scheduling Example

Strategic Rationale (SR) model

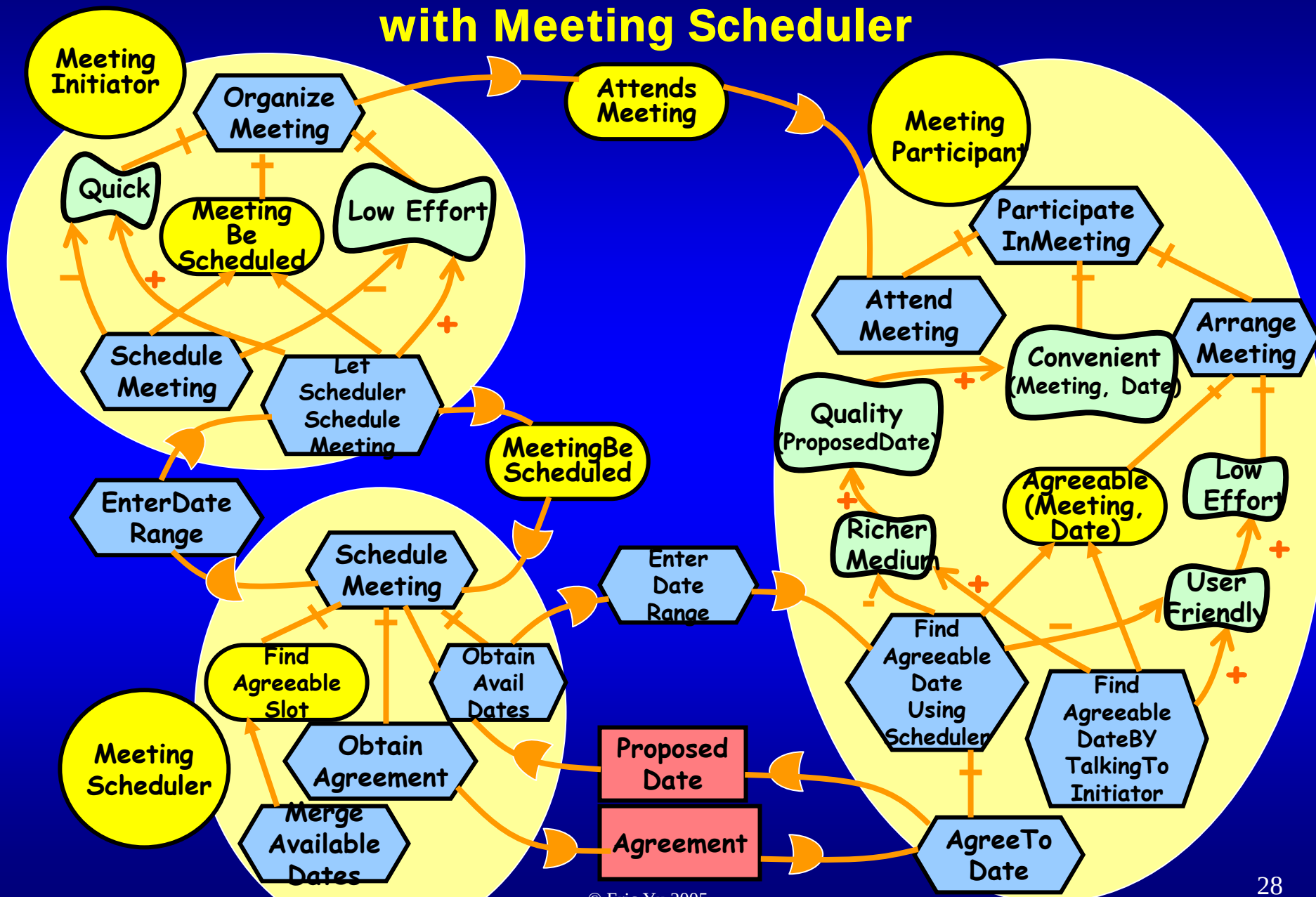
- Ask "Why", "How", "How else"

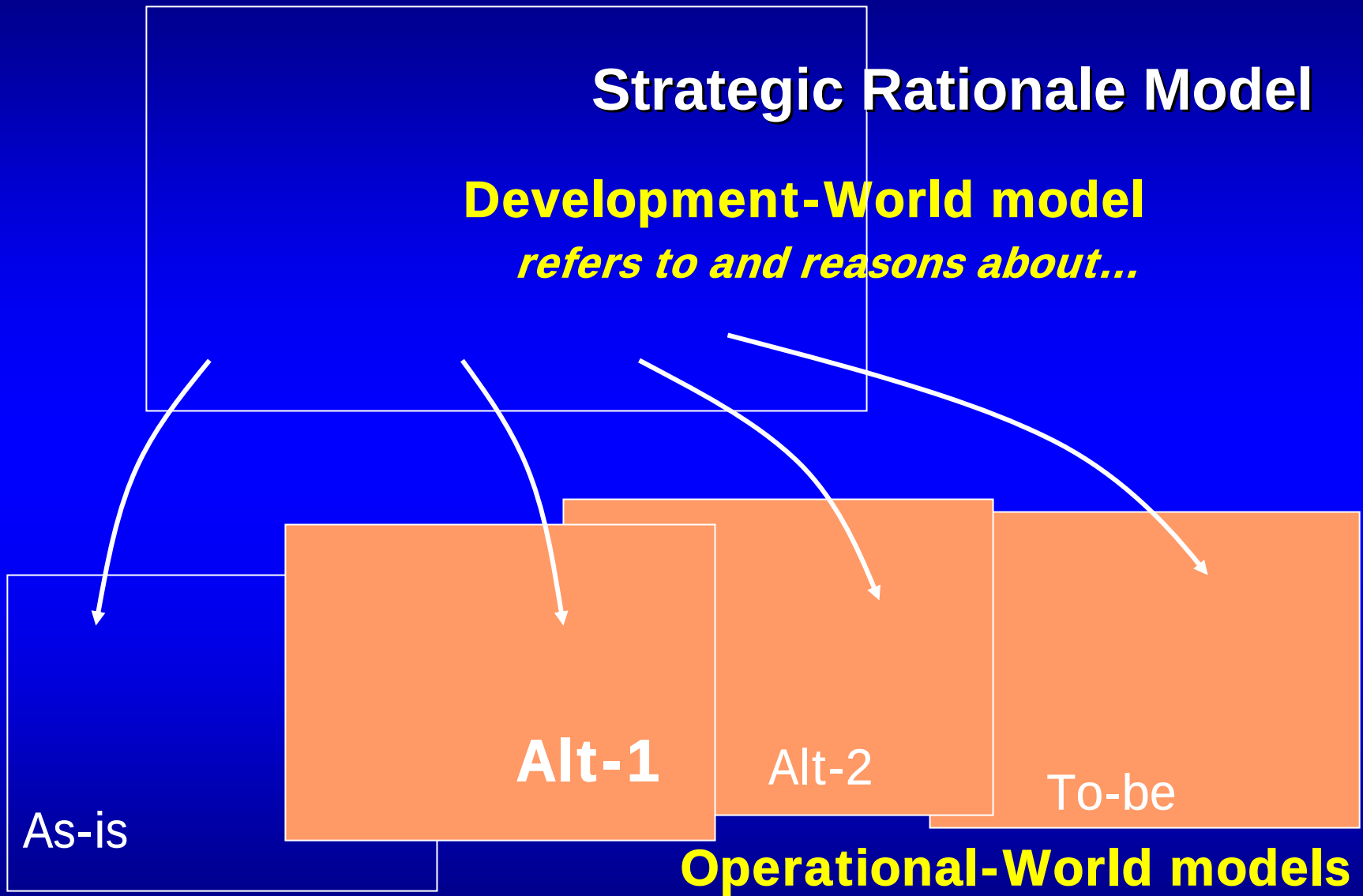


Scheduling meeting ...with meeting scheduler



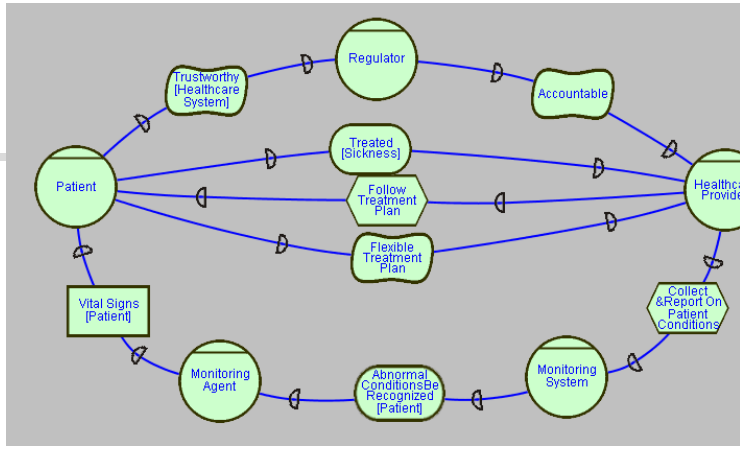
"Strategic Rationale" Model with Meeting Scheduler





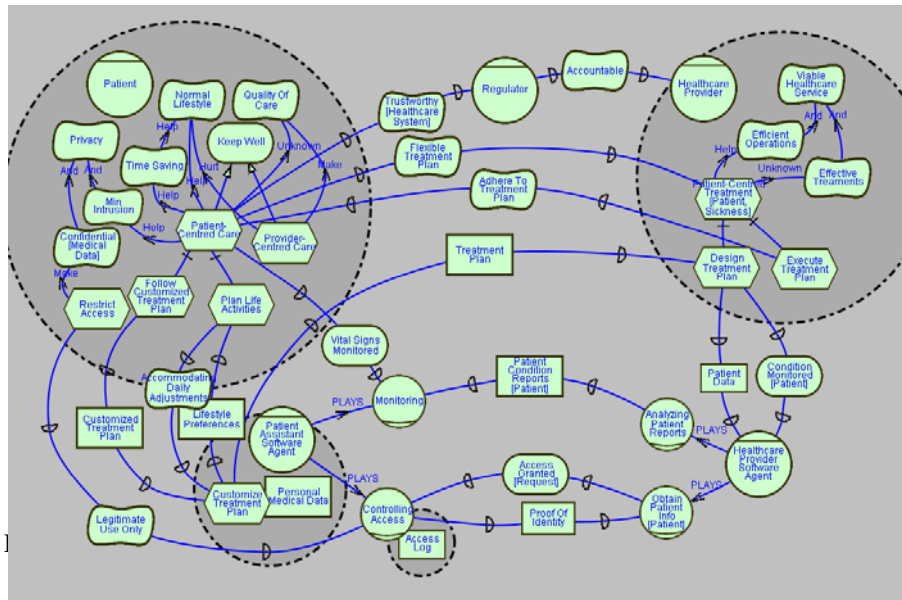
Strategic Dependency Models

Analysis and Design Support

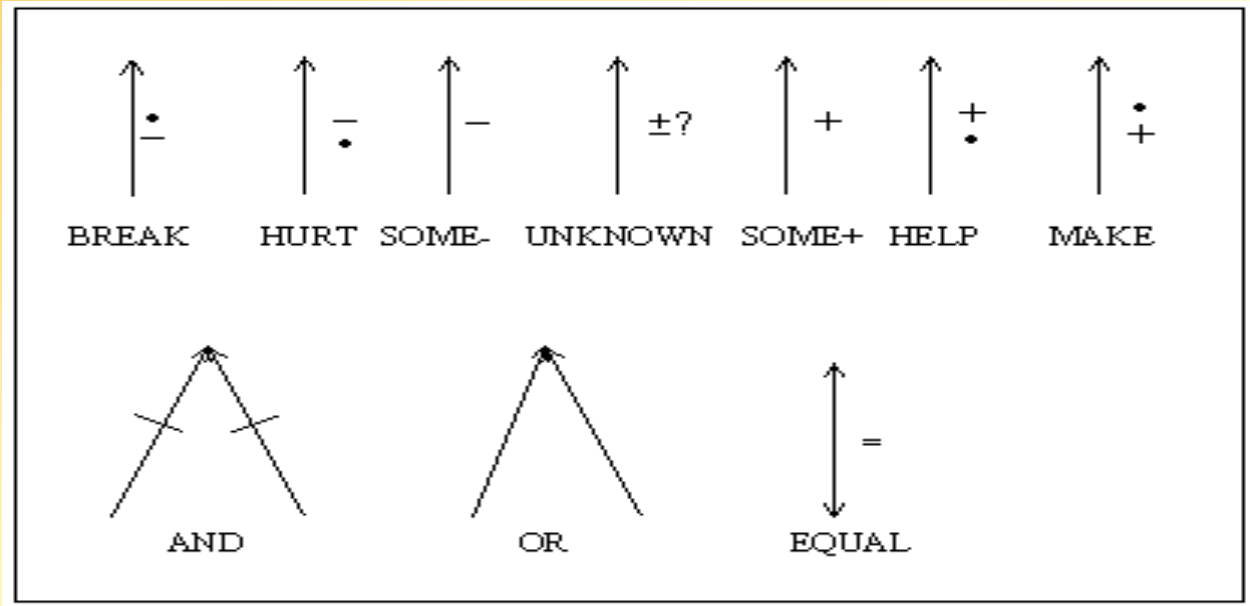


- opportunities and vulnerabilities
  - ability, workability, viability, believability
  - insurance, assurance, enforceability
  - node and loop analysis

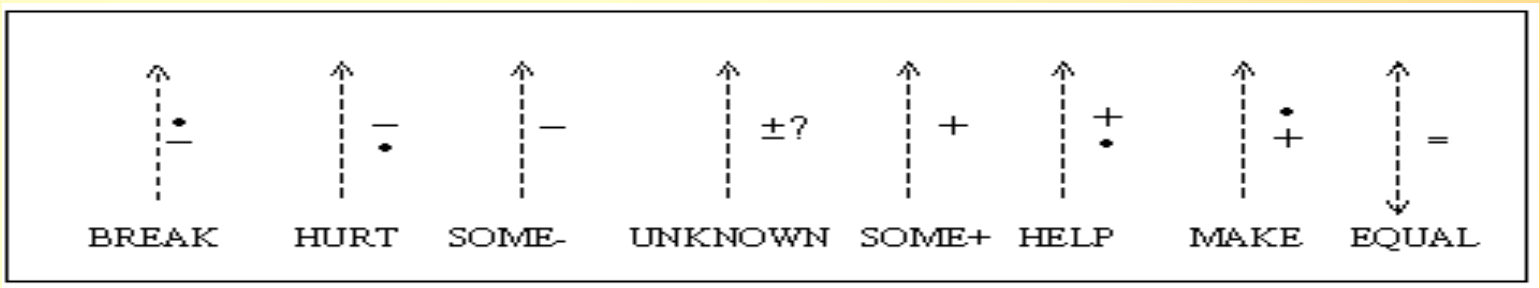
- design support
  - raising issues
  - exploring alternatives
  - evaluating, making tradeoffs
  - justifying, settling
  - based on qualitative reasoning



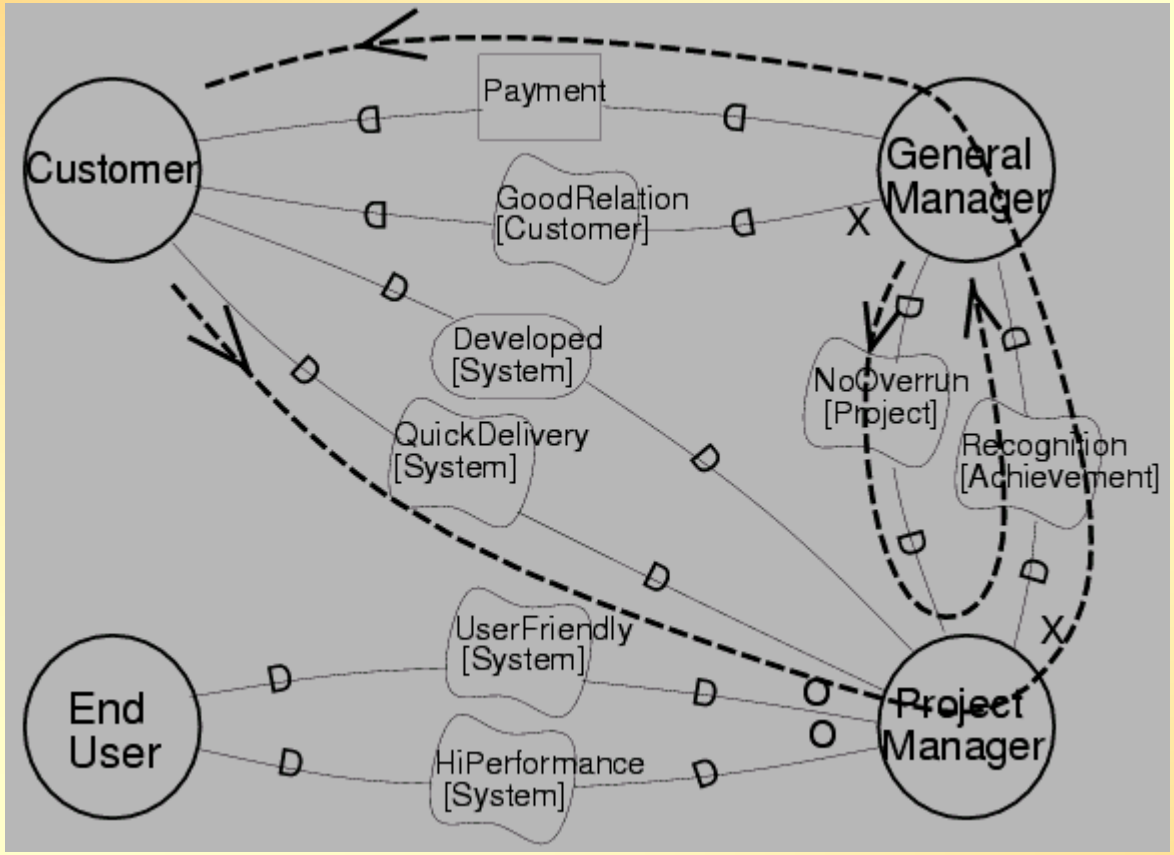
Softgoal Operationalizations: Contribution Relationship



Side-effects to softgoals: Correlation Relationship

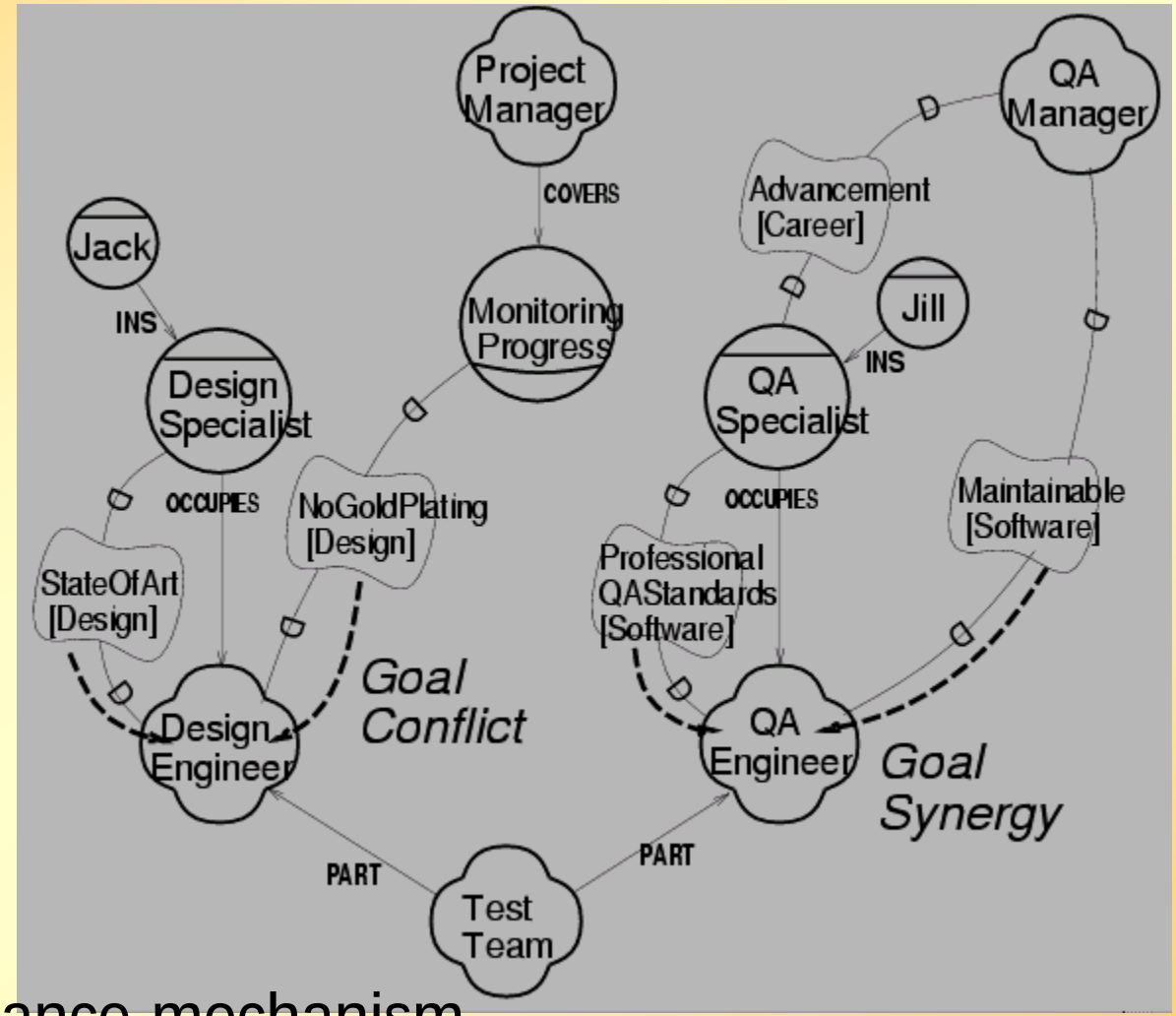


Analyzing vulnerabilities



- Example of enforcement mechanism
  - Reciprocal dependency
- Loop analysis

Analyzing vulnerabilities



- Example of assurance mechanism
  - Goal synergy or conflict
- Node analysis

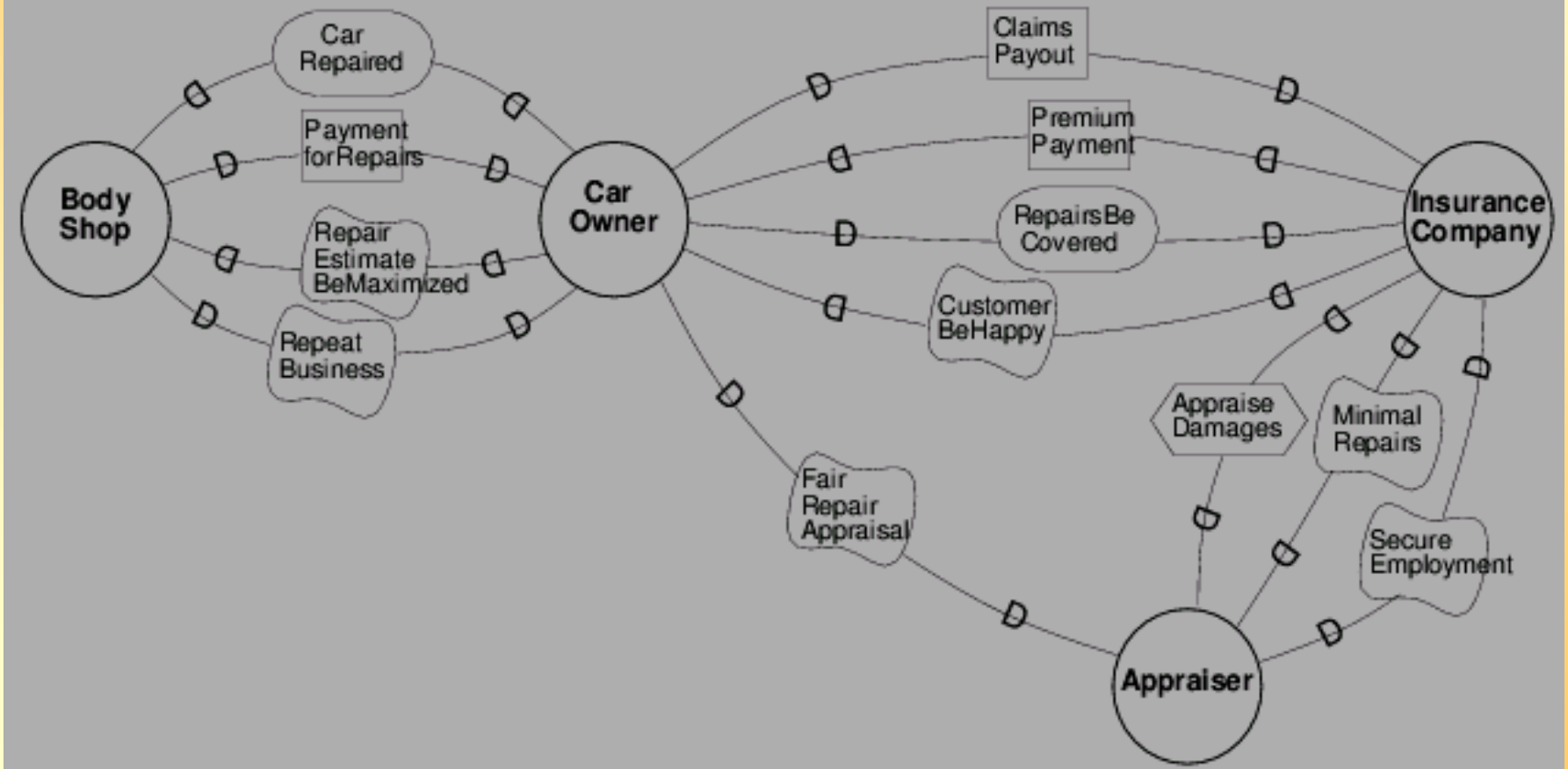
Another Example:

Car insurance

From: E. Yu. WITS94.

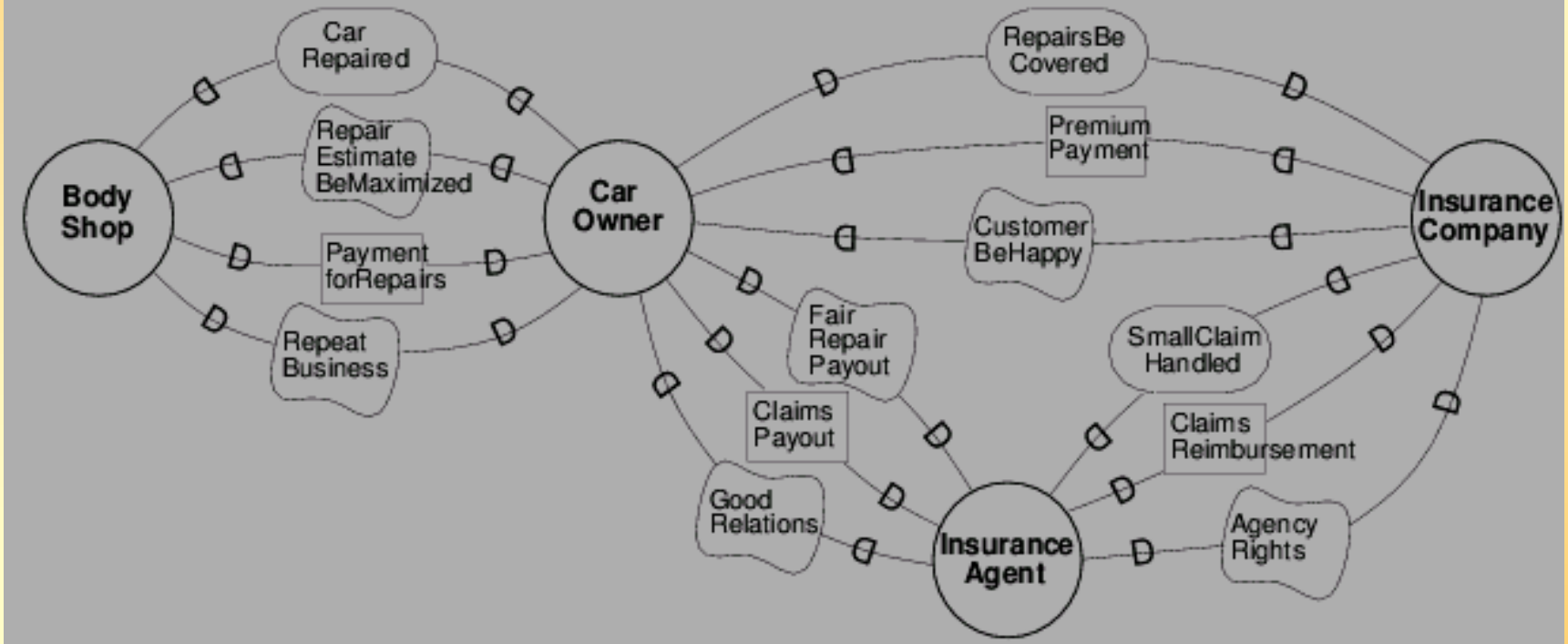
The Strategic Dependency Model

automobile insurance – example 1



The Strategic Dependency Model

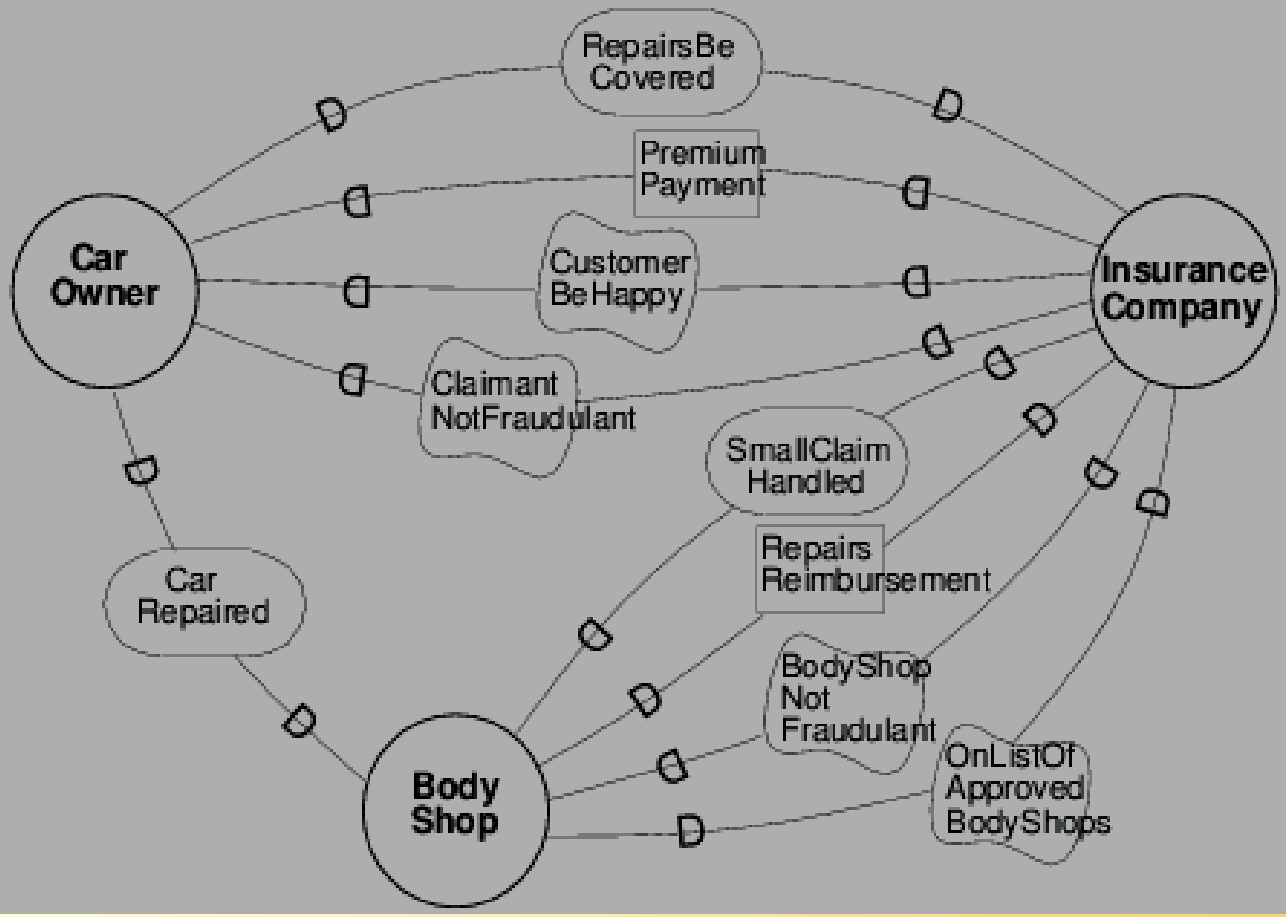
auto insurance – example 2
"Let the Insurance Agent handle it."



examples taken from: Hammer & Champy 1993 – Reengineering the Corporation, pp. 137–143.

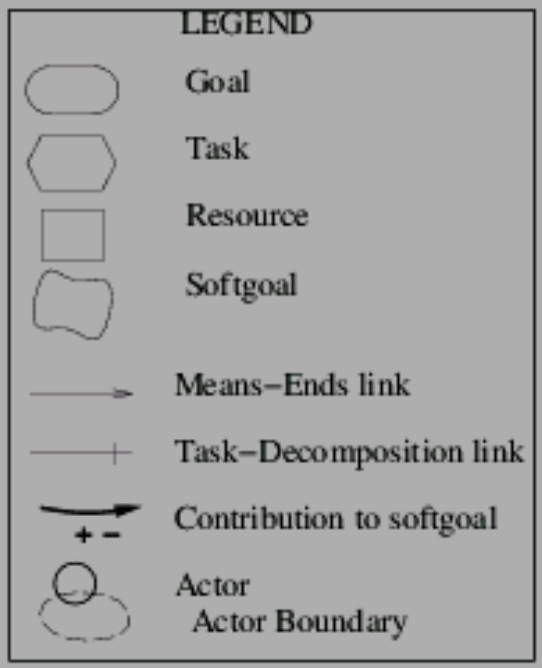
The Strategic Dependency Model

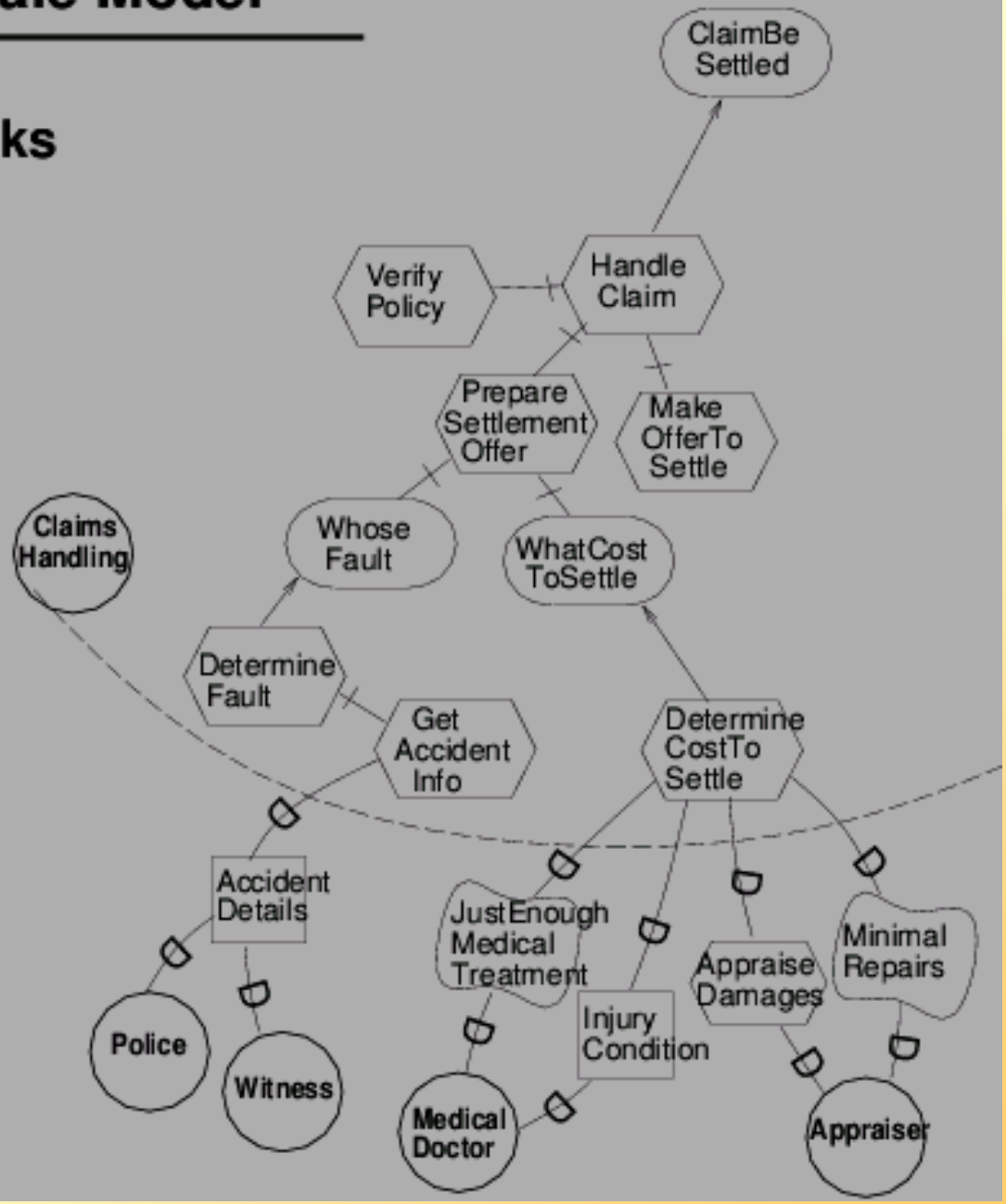
auto insurance – example 3
"Let the Body Shop handle it."



The Strategic Rationale Model

means–ends links and task decomposition links



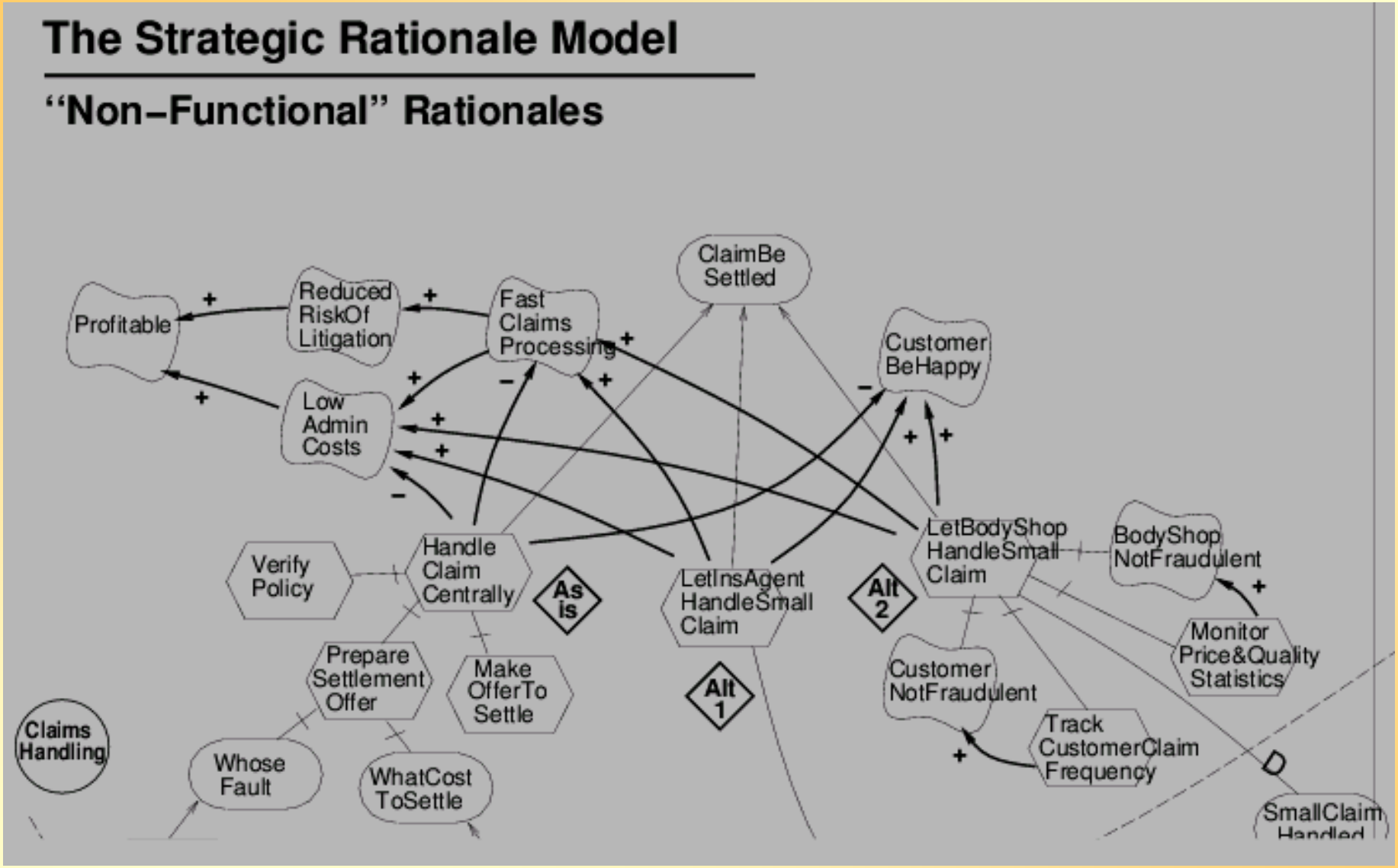


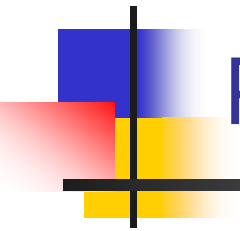
The Strategic Rationale Model

"Functional" Alternatives

The Strategic Rationale Model

"Non-Functional" Rationales





Part 4 – Exercise

Exercise:

Work out a small *i** modelling example from your own experience

- Pick an area that you know well, or have thought about recently
- Characteristics to look for:
  - 2 or more actors (possibly with multiple roles)
  - Different strategic interests, possibly conflicting
  - Some freedom of action in operational processes
- SD models (before vs. after, as-is vs. to-be)
- SR model showing the reasoning behind the change
- Use SR to explore further alternatives

Example areas (just to get your imagination going...)

- E-business models – clicks vs. bricks, B2C, B2B
- Educational systems, organizational structures – online vs. classroom learning
- Healthcare – payment methods, prevention vs. treatment
- Government/administrative processes – multi-step approval processes, can they be concurrent?
- Financial services – linking to purchase patterns?
- Food production, preparation, delivery, consumption – cultural preferences, differences. Eg. Pizza online?
- Entertainment – personalized video programming?
- Transportation – parking & traffic congestion
- Publishing – e-books, e-journals...

Once you have a basic model...

(an as-is SD, and an initial SR)

Consider whether these are applicable:

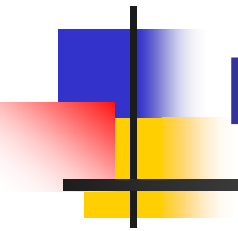
- Producer/consumer relationships
  - What do they want from each other?
- Regulators, evaluators, ... - why are they needed?
- Intermediaries, eg. Brokers
- Markets vs. hierarchies
- Roles vs. holders of roles

For ideas about alternative SD's, consider:

- Eliminating or adding actors (eg. Intermediaries)
- Shifting responsibilities between 2 actors (move up/down along means-ends chain)
- Changing the dependency type (eg. Softgoal to hardgoal)
- Reassigning roles to different agents/positions

Further ideas about sources of disturbances prompting change

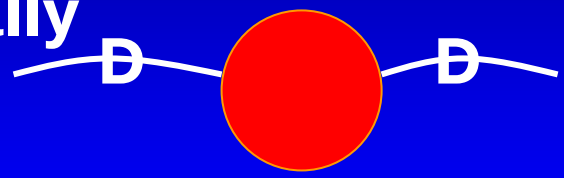
- New technologies – Internet, mobile phone, GIS, web services, digital imaging, ...
- New knowhow, techniques – preventive healthcare...
- Migration of people, with knowhow, attitudes, resources – gain/loss
- Changes in attitudes – eg. Notions of quality, safety...
- Changes in supply/demand of important resources – eg. oil, time – abrupt change or critical limits
- Changes in legislation, policies, authorities, standards, dominant players, ...



Part 5 – AO modelling principles

i* objectives, premises, key concepts

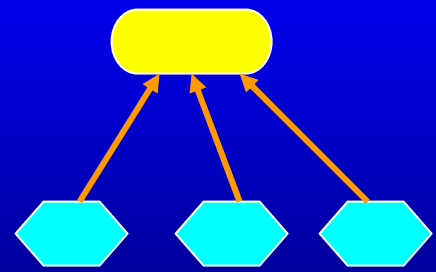
- **Actors are semi-autonomous, partially knowable**



- **Strategic actors, intentional dependencies**

wants and abilities

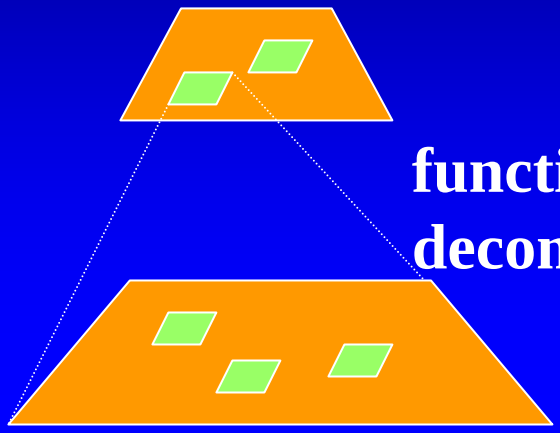
- **have choice, reasons about alternate means to ends**



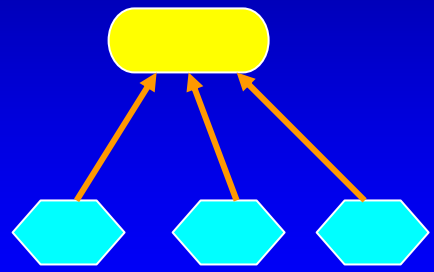
means-ends alternatives

*i** modeling

1. explicit intentionality → goals



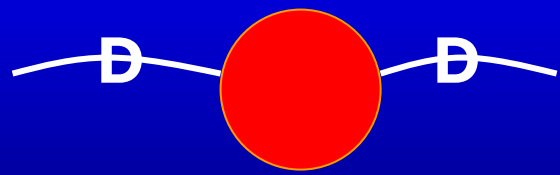
functional
decomposition



means-ends
alternatives

2. implicit intentionality → agents

inputs
outputs



wants and
abilities

So what are the important concepts for Agent Orientation as a Modelling Paradigm ?

- Intentionality
- Autonomy
- Sociality
- Identity & Boundaries
- Strategic Reflectivity
- Rational Self-Interest

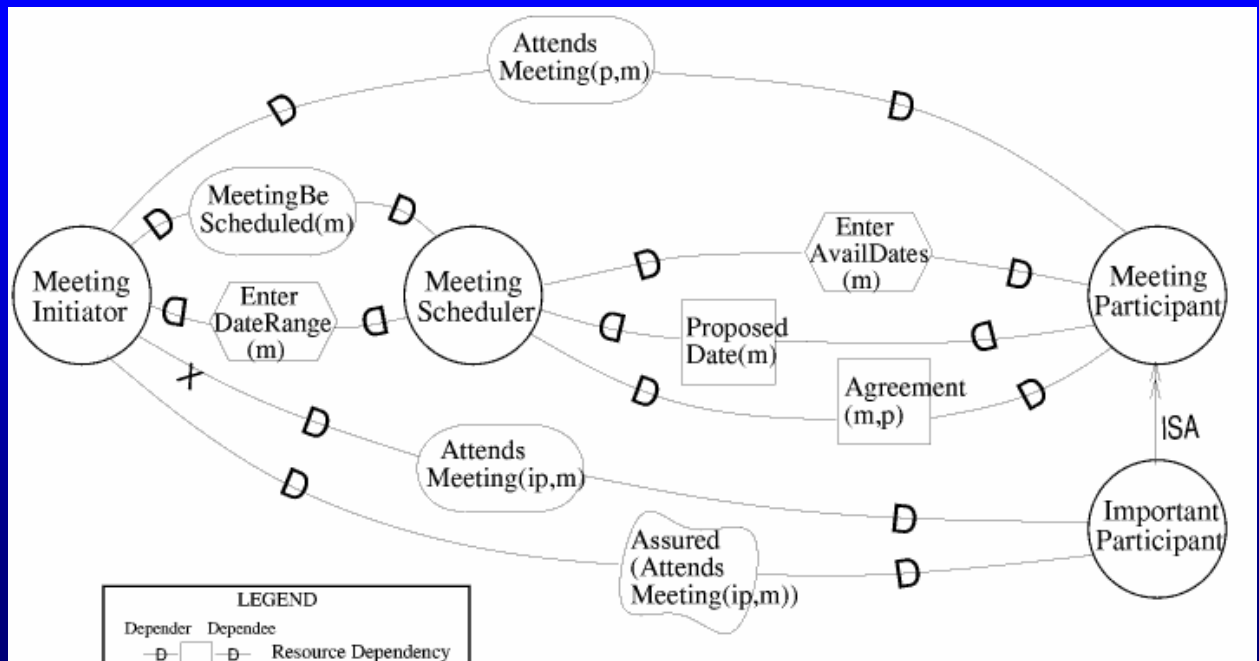
Contrast
- OO modelling
- AO software implementation technology

E. Yu. "Agent Orientation as a Modelling Paradigm," Wirtschaftsinformatik, April 2001.

Agent Oriented Modelling

1. Intentionality

- Agents are intentional.
- Agent intentionality is externally attributed by the modeller.
- Agency provides localization of intentionality.
- Agents relate to each other at an intentional level.

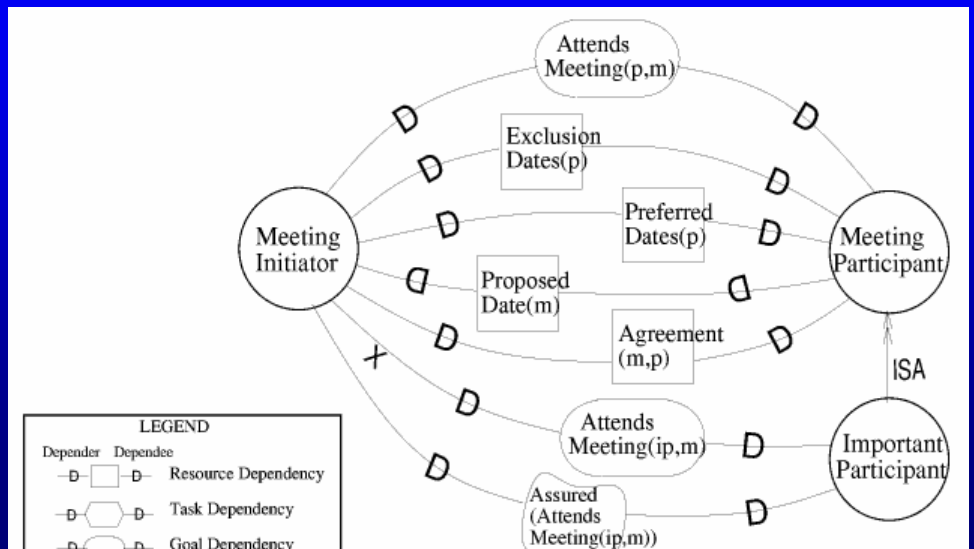


Meeting Scheduling Example

Agent Oriented Modelling

2. Autonomy

- An agent has its own initiative, and can act independently. Consequently, for a modeller and from the viewpoint of other agents:
  - its behaviour is not fully predictable.
  - It is not fully knowable,
  - nor fully controllable.
- The behaviour of an agent can be partially characterized, despite autonomy, using intentional concepts.



Agent Oriented Modelling

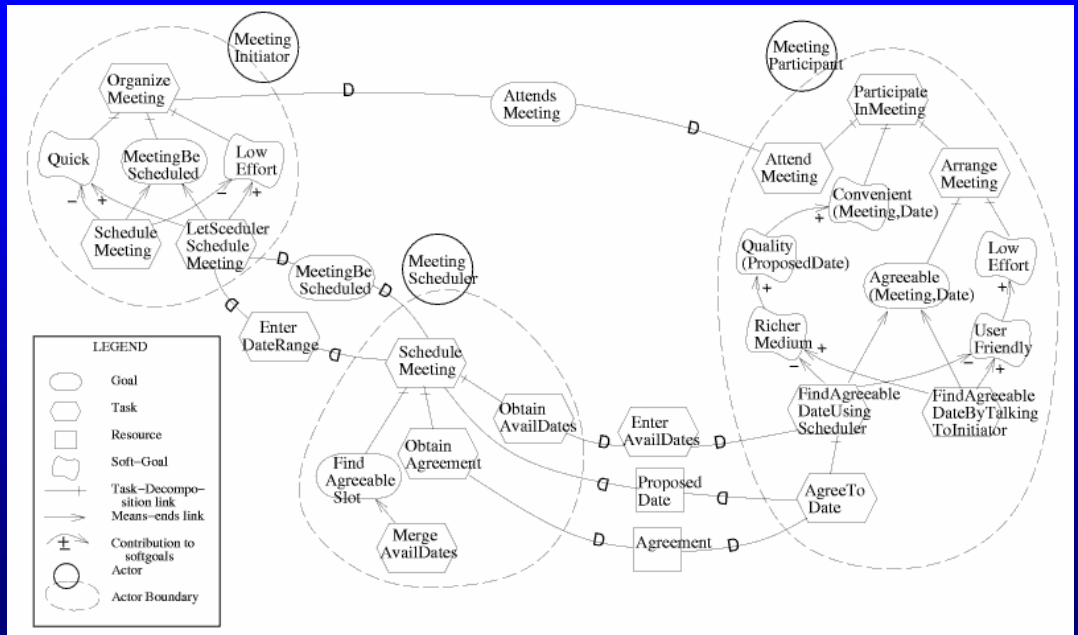
3. Sociality

- An agent is characterized by its relationships with other agents, and not by its intrinsic properties alone.
- Relationships among agents are complex and generally not reducible.
- Conflicts among many of the relationships that an agent participates in are not easily resolvable.
- Agents tend to have multi-lateral relationships, rather than one-way relationships.
- Agent relationships form an unbounded network
- Cooperation among agents cannot be taken for granted.
- Autonomy is tempered by sociality.

Agent Oriented Modelling

4. Identity & Boundaries

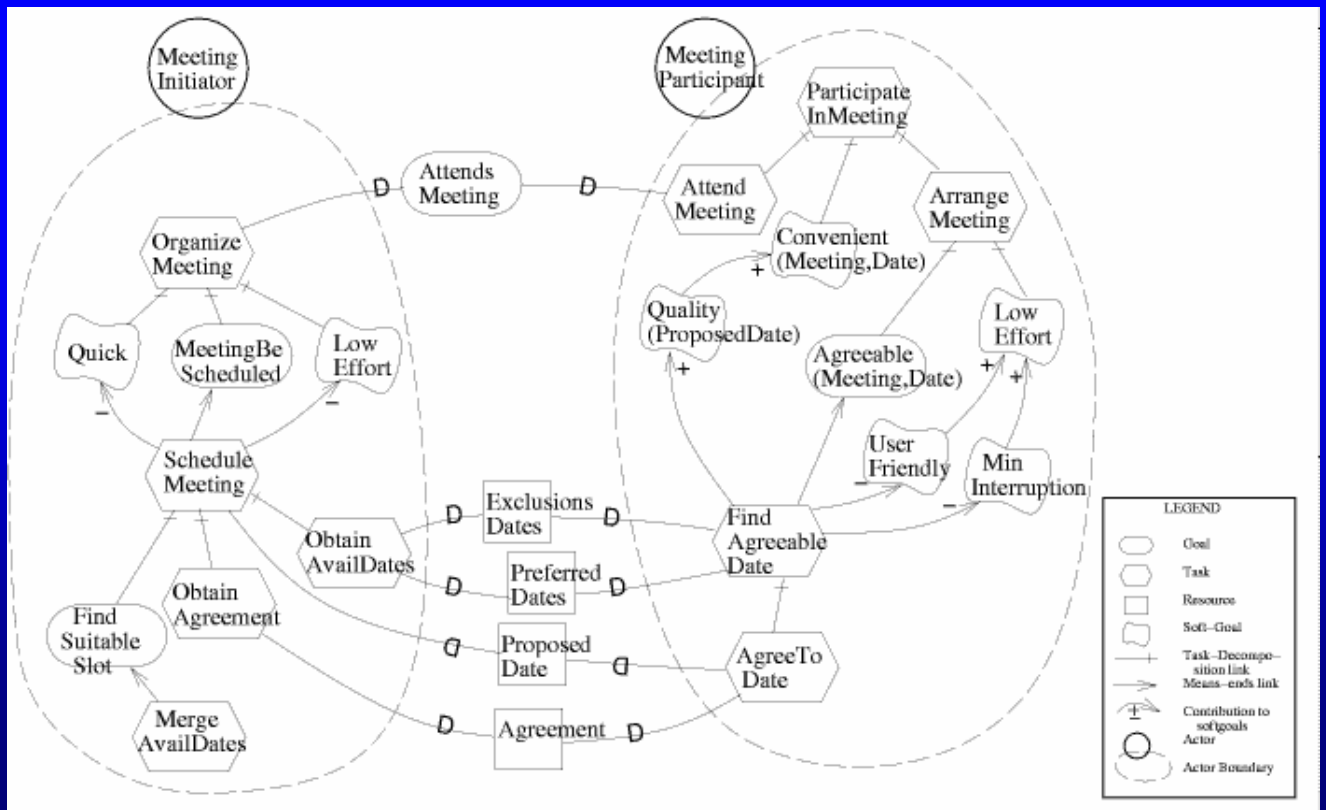
- Agents can be abstract, or physical.
- The boundaries, and thus the identity, of an agent are contingent and changeable.
- Agent, both physical and abstract, may be created and terminated.
- Agent behaviour may be classified, and generalized (following OO concepts).



Agent Oriented Modelling

5. Strategic Reflectivity

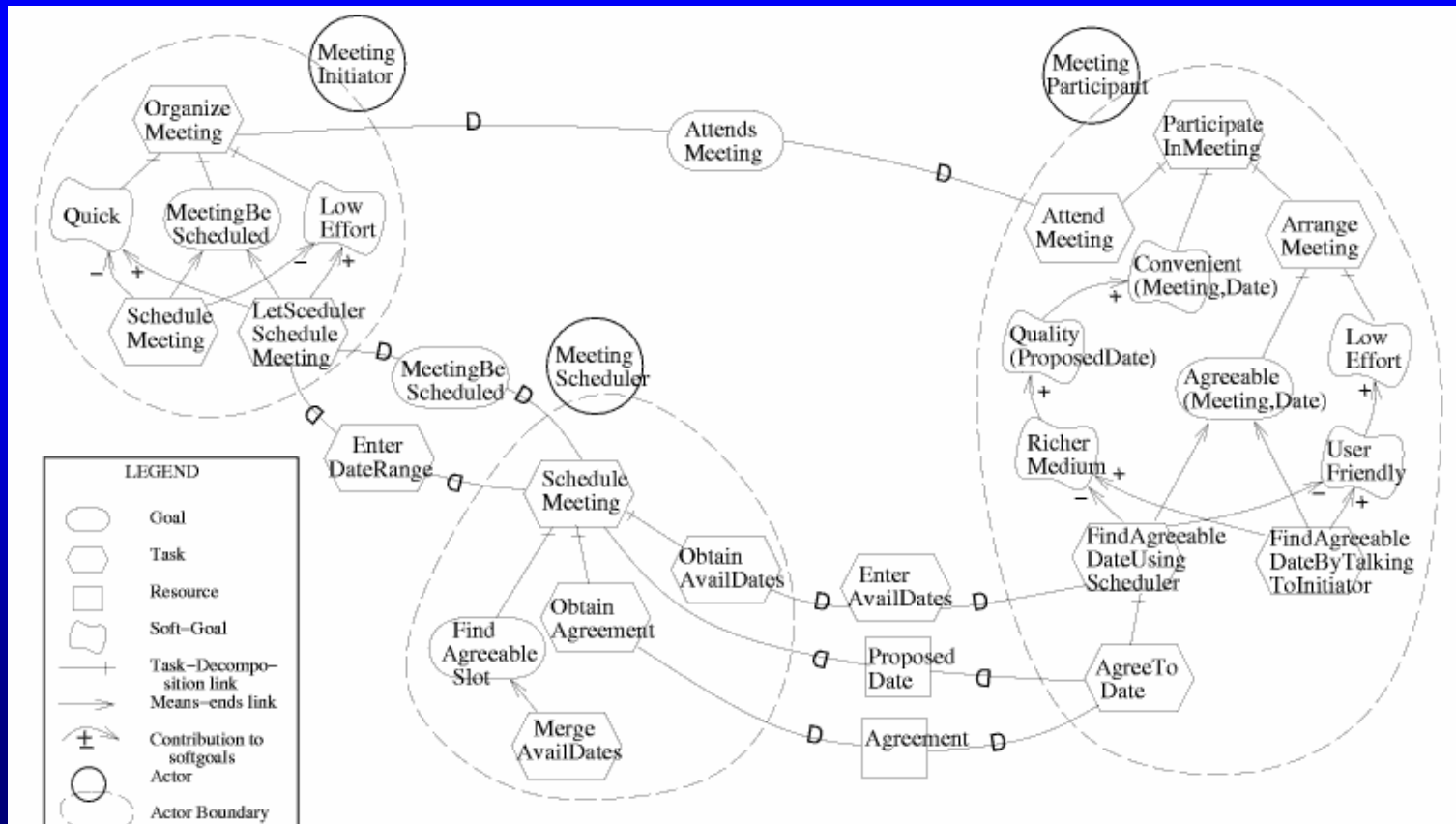
- Agents reflect upon their own operations.
- "Development world" deliberations and decisions are strategic with respect to the "operational world".

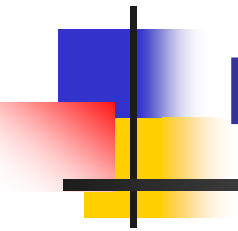


Agent Oriented Modelling

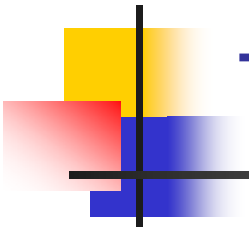
6. Rational Self-Interest

- An agent strives to meet its goals.
- Self-interest is in a context of social relations.
- Rationality is bounded and partial.





Part 6 – Ongoing work

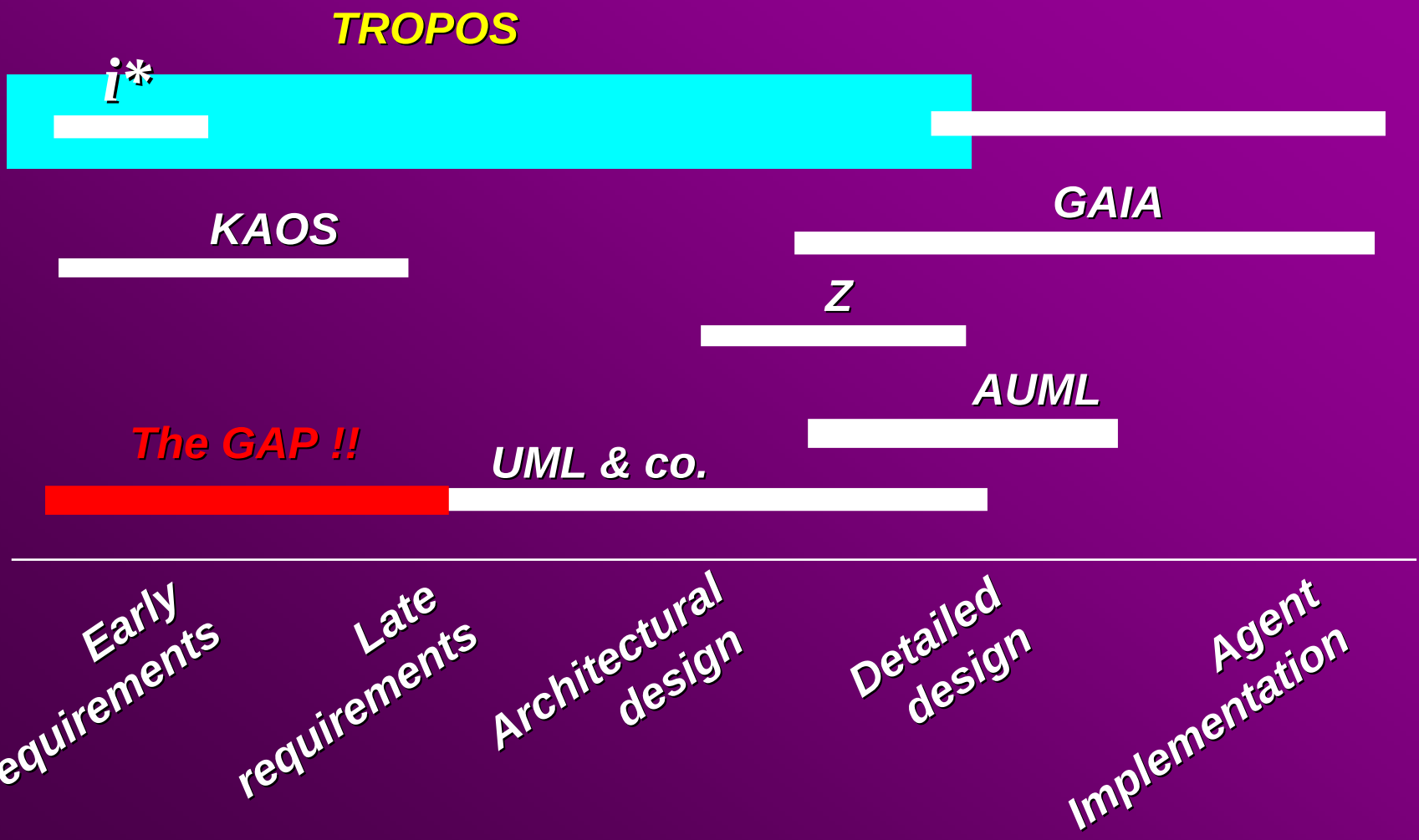


Tools & Methods

- Graphical visualization
- Qualitative reasoning - graph evaluation
- Simulation, scenario animation – “what if”
- Knowledge base support
- Complementary techniques
  - Quantitative evaluation
- Formalization
  - Structural representation of socio-technical relationships
  - Intentional concepts – goals, beliefs, ...
- Methodological guidelines

Agent-Oriented Software Development

[J. Mylopoulos AOIS'99 Invited Talk]



This afternoon – industrial experiences

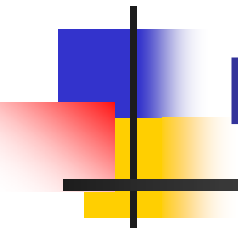
- 14:00-16:30
  Four presentations of industrial case studies
  "Bed Management Organizational Analysis with i*: The case of the Saint Luc University Clinics" (Manuel Kolp, University of Louvain, Belgium)

  "Understanding the Requirements of a Decision Support System for Integrated Production in Agriculture" (Anna Perini, ITC-irst, University of Trento, Italy)

  "Some Lessons Learned from Using i* Modelling in Practice" (Oscar Pastor, Valencia University of Technology, Spain)

  "Modelling Complex Air Traffic Management Systems with i*: Tales from the Coal Face"
  (Neil Maiden and Sara Jones, City University, London)

- 16:30-17:00
  Panel session moderated by Ian Alexander



References

See

http://www.cs.toronto.edu/km/istar/

http://www.fis.utoronto.ca/~yu