Perspective of Verifiable and Evolvable e-Society

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COE Program "Verifiable and Evolvable e-Society" (1/3)

- COE Program - Overview
  - Targeted Support for Creating World-level Research and Education Bases, Started FY 2002
  - National recognition of excellent group
- "Verifiable and Evolvable e-Society" Program
  - One of 12 computer science related programs so far granted
  - Granted in 2004 in "Revolutionary Area " (28 out of 330)
  - Only one program in software engineering and dependability area
- Establish research and education bases on the science and technology for Trustworthy e-Society from two standpoints:
  - Verification and Evolution of e-Society
    - Formal logic, software engineering and artificial intelligence
  - Infrastructures for Trustworthy e-Society
    - Algorithm , human interface, network and hardware
  - 5 year project

COE Program "Verifiable and Evolvable e-Society " (2/3)

- Create a research base on Trustworthy e-Society
  - Formal description of e-Society
  - Trustworthy requirements and their verification methods
  - Modeling of e-Society
  - Verification and simulation mechanisms
  - Evolution of e-Society
  - Trustworthy infrastructures for e-Society

COE Program "Verifiable and Evolvable e-Society " (3/3)

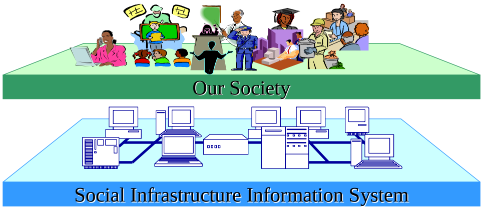
- Create an education base in Trustworthy e-Society area
  - Train Ph.D level researchers and engineers in the design, verification and implementation of e-Society / e-Government
  - Establish curriculum
    - 15 courses that we have on trustworthy information systems
      - Logic, formal systems, verification, software design, security, networks, hardware ...
    - New courses in e-Government / e-society (NTT Data Corp.)
      - Large scale information system
      - Social information systems
  - 30 Ph.D students in 5 years

Collaborations

- National collaborators
  - NTT Data Corporation
    - Research on verification of enterprise information systems
    - Collaborated Unit on "e-Society Systems" in School of Information Science
  - INTEC Corporation and Toyama Prefecture
    - Study on the legal reasoning in the administration of Toyama prefecture
  - Hokuriku NES Corporation
    - Formal methods for security protocol verification
- International collaborators
  - AT&T Labs-Research, EPFL, Politecnico di Milano,
  - NICTA (to be considered)

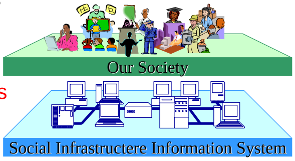
e-Society

- e-Society is a part of social system which is realized by information system
  - Supports fundamental part of our social activities
  - Politics, administration, business, judicature, education, ...
  - Infrastructure of our society
- e-Society should be trustworthy.



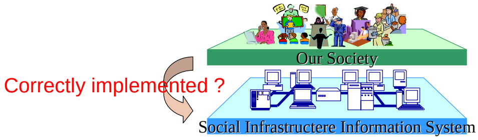
Requirements for Trustworthy e-Society

1. Correctness
   Are the functions correct? （"Is my tax amount correctly calculated?"）
2. Accountability
   Can questions about the information system answer be answered?
3. Security
   No illegal data access, Privacy protected…
4. Fault Tolerance
   Can tolerate failures and accidents?
5. Evolvability
   Can e-society system be changed according to the change of society?
6. Trustworthy infrastructures
   Supported by reliable network and hardware systems



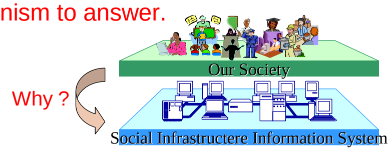
Correctness

- Requires that e-Society information system correctly implements our real society.
  - Structures and functions of e-Society have to be consistent with the laws and systems of our society.
  - Is the tax amount correctly calculated ?
- The most important requirement to e-Society



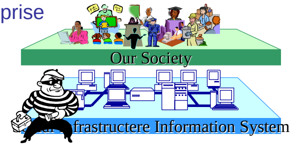
Accountability

- Requires that it is possible to answer questions or explain about e-Society
  - Why is my tax amount correct?
  - You or the information system itself has to answer.
- As details of e-Society is hidden inside its complex information system, there must be some mechanism to answer.



Security

- Requires that information security is observed according to what are explicitly or implicitly defined in our security-related social systems and laws.
  - Is your private data illegally accessed or altered?
  - Is it possible for enterprise data to be stolen?



Fault Tolerance

- Requires that e-Society continues to operate its fundamental functions and services despite failures and accidental events of individuals, organizations and underlying network and hardware systems.

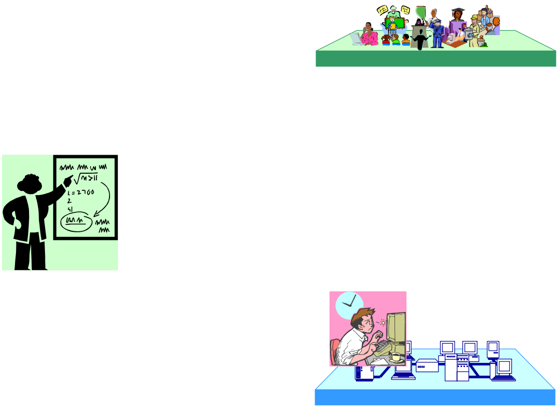
Evolvability

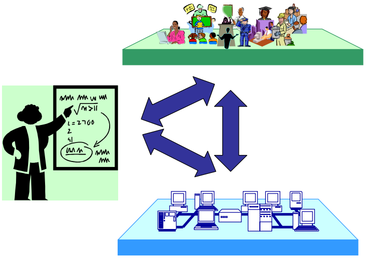
- Requires that e-Society information system could be changed according to the change of our society.
  - Lack of evolvability will make e-Society obsolete, and prevents the progress of our society.

Trustworthy e-Society Through Advanced Computer Science

- A large body of computer science has been formed and used to construct complex social infrastructure information systems.
  - Software, network, hardware, AI, algorithms, logic,....
  - The information systems have supported and continue to support fundamental part of our lives.
- Still,...
  - They are not trustworthy enough to leave our lives in the coming e-Society age.
  - More computer science has to be put into the development of information system,

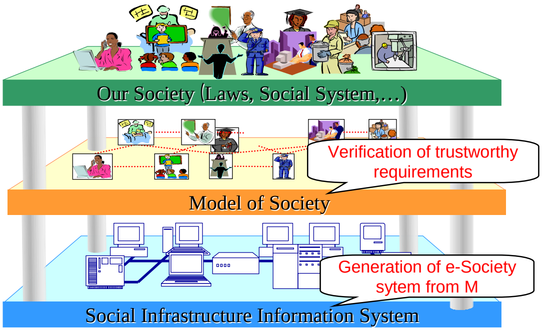
  At the same time
  - More social structures have to be explicitly considered in the design of e-Society systems.



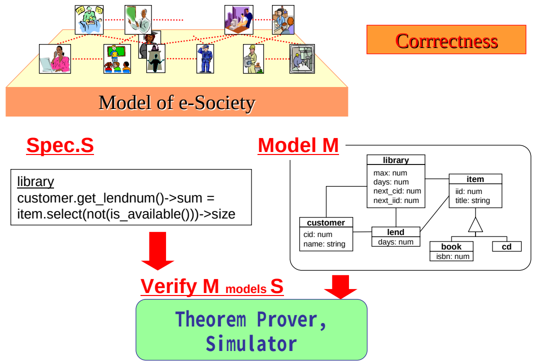


Build trustworthy e-Society on advanced computer science and sociological considerations.

Model Driven Approach to Trustworthy e-Society


Our Society (Laws, Social System,…)
Verification of trustworthy requirements
Model of Society
Generation of e-Society sytem from M
Social Infrastructure Information System

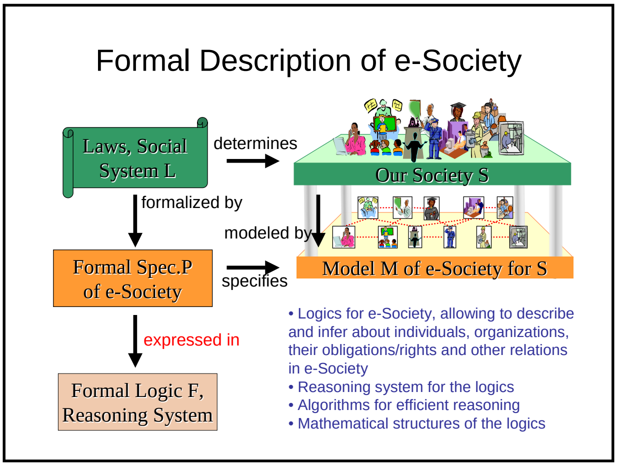
Verification of e-Society, An Example



Spec.S

library
customer.get_lendnum()->sum = item.select(not(is_available()))->size

Some Challenges



Formal Description of e-Society

Laws, Social System L

determines

Our Society S

formalized by

modeled by

Formal Spec.P of e-Society

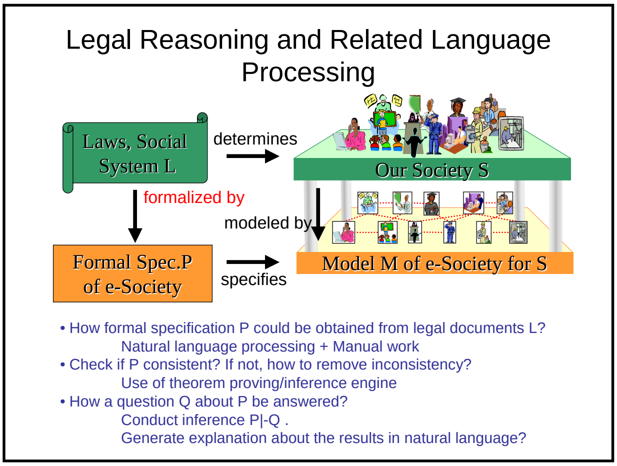
specifies

Model M of e-Society for S

expressed in

Formal Logic F, Reasoning System

- Logics for e-Society, allowing to describe and infer about individuals, organizations, their obligations/rights and other relations in e-Society
- Reasoning system for the logics
- Algorithms for efficient reasoning
- Mathematical structures of the logics



Legal Reasoning and Related Language Processing

Laws, Social System L

determines

Our Society S

formalized by

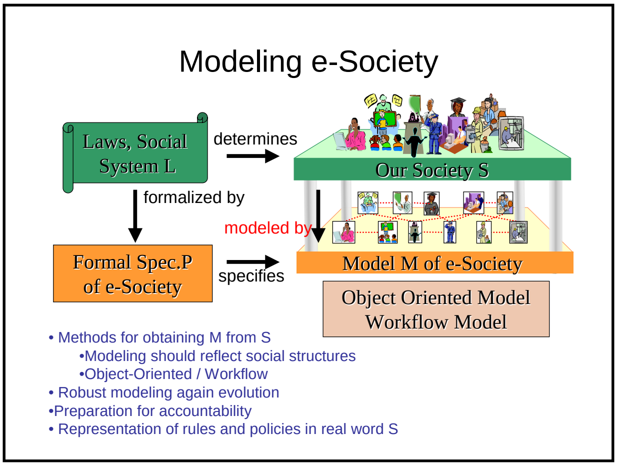
modeled by

Formal Spec.P of e-Society

specifies

Model M of e-Society for S

- How formal specification P could be obtained from legal documents L?
  Natural language processing + Manual work
- Check if P consistent? If not, how to remove inconsistency?
  Use of theorem proving/inference engine
- How a question Q about P be answered?
  Conduct inference P|-Q .
  Generate explanation about the results in natural language?



Modeling e-Society

Laws, Social System L

determines

Our Society S

formalized by

modeled by

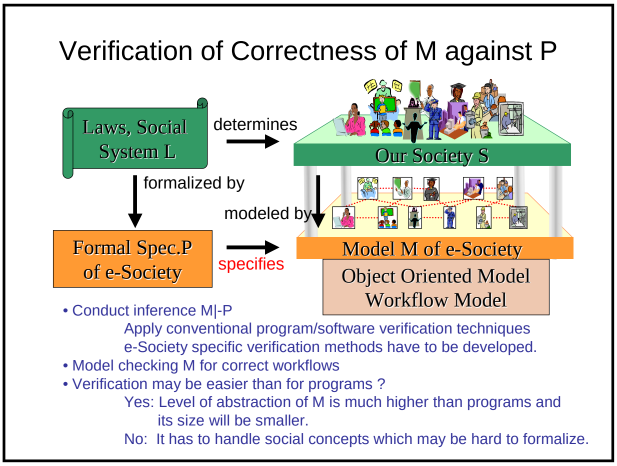
Formal Spec.P of e-Society

specifies

Model M of e-Society

Object Oriented Model Workflow Model

- Methods for obtaining M from S
  - •Modeling should reflect social structures
  - •Object-Oriented / Workflow
- Robust modeling again evolution
- •Preparation for accountability
- Representation of rules and policies in real word S



Verification of Correctness of M against P

Laws, Social System L

determines

Our Society S

formalized by

modeled by

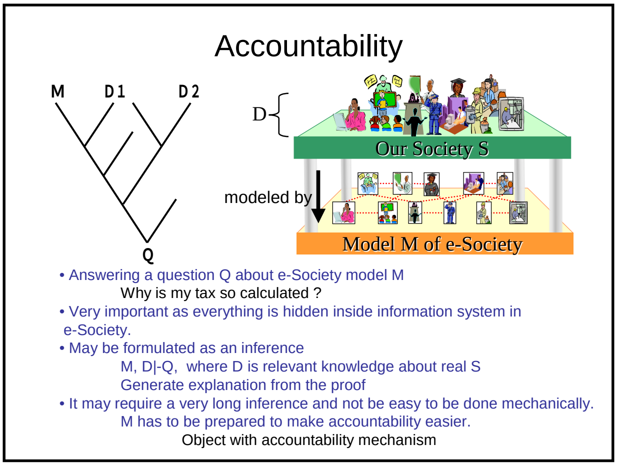
Formal Spec.P of e-Society

specifies

Model M of e-Society

Object Oriented Model Workflow Model

- Conduct inference M|-P
  Apply conventional program/software verification techniques
  e-Society specific verification methods have to be developed.
- Model checking M for correct workflows
- Verification may be easier than for programs ?
  Yes: Level of abstraction of M is much higher than programs and its size will be smaller.
  No: It has to handle social concepts which may be hard to formalize.



Accountability

M D1 D2

Q

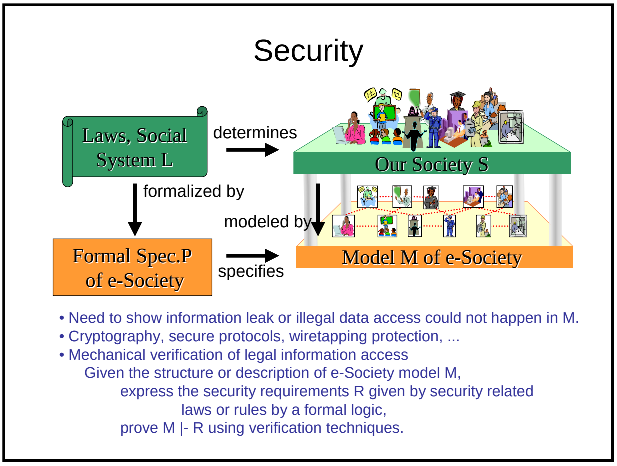
D

Our Society S

modeled by

Model M of e-Society

- Answering a question Q about e-Society model M
  Why is my tax so calculated ?
- Very important as everything is hidden inside information system in e-Society.
- May be formulated as an inference
  M, D|-Q, where D is relevant knowledge about real S
  Generate explanation from the proof
- It may require a very long inference and not be easy to be done mechanically.
  M has to be prepared to make accountability easier.
  Object with accountability mechanism



Security

Laws, Social System L

determines

Our Society S

formalized by

modeled by

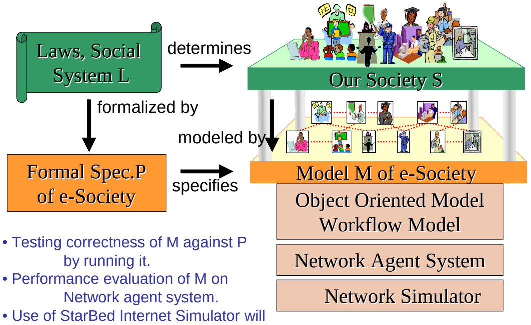
Formal Spec.P of e-Society

specifies

Model M of e-Society

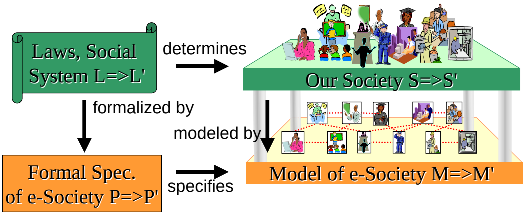
- Need to show information leak or illegal data access could not happen in M.
- Cryptography, secure protocols, wiretapping protection, ...
- Mechanical verification of legal information access
  Given the structure or description of e-Society model M,
  express the security requirements R given by security related laws or rules by a formal logic,
  prove M |- R using verification techniques.

e-Society Simulator



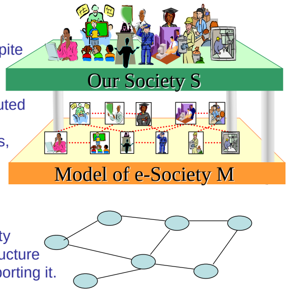
- Testing correctness of M against P by running it.
- Performance evaluation of M on Network agent system.
- Use of StarBed Internet Simulator will help more realistic evaluation.

Evolution of e-Society



- In the change P=>P' of social specification, how to find and remove inconsistency in P' ?
- How should model evolution M=>M' be done according to P=>P' ?
  Aspects, Ontology, Versioning, Components, ...
  Need to investigate how P and M are related.
  How individuals, organization and their relations are modeled in M ?

Dependability



- M needs to continue its functions despite failures and accidents occurred to individuals and organizations in M.
  - Apply FT technologies for distributed systems
    Group membership, Consensus, atomic broadcast,...
  - What are e-Society specific problems, which are not found in the computer/network systems ?
- What is the implication of the e-Society dependability requirements to infrastructure networks and computer systems supporting it.

Infrastructures for Trustworthy e-Society

- Mathematical infrastructure
  - Algorithmic study for efficient reasoning systems
- Advanced human interface infrastructure
  - Secure exchange of information between people and the e-Society, multimedia-based interactive access system, human interface for disabled people, shared intelligent spaces that make use of robots
- High-reliability network infrastructure
  - Reliability and security technologies for constructing and operating heterogeneous internet and ubiquitous network infrastructures for e-Society
- High-reliability hardware infrastructure
  - Processor design through fully automated synthesis, based on a specification description; fault tolerant architecture; and a highly reliable real-time operating system

Summary

- COE programs in general
- COE program "Verifiable and Evolvable e-Society"
  - Trustworthy requirements
    - Correctness, Accountability, Security, Evolvability, Fault-tolerance
  - Model driven approach + Formal approach + Sociological approach
- Some challenges