Goal Oriented Requirements Engineering: Basics, Past, Current, and Future Work

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Outline

- GORE (Goal-Oriented Requirements Engineering) Motivation
- Goal Model Basics
  - Example Application
  - Example: Goal modeling with i*
  - Frameworks and further examples
- GORE Extensions/Applications: Past and Current Work (Selected Examples)
  - Goal Model Analysis
  - Uncertainty
  - Business Intelligence
  - Adaptation & Evolution
  - Run-time Analysis
  - Security
  - Alignment & Evolution
- Community & Events
- Tool Support
- Challenges & Open Topics
- References
Why Goal-Oriented Requirements Engineering?

- Most systems today are socio-technical, e.g.,
  - E-business; E-learning; E-health; E-government
  - Energy, environment, transportation

- Complex relationships among stakeholders
  - Help stakeholders understand their needs:
    - E.g., security, privacy, trust, profitability, market positioning, strategic alliances, intellectual property, ...
  - Help each other achieve what they want
  - Understanding “why”, not just “what”

- Technology embedded into stakeholder lives

- Goal-Oriented Requirements Engineering
  - Captures stakeholder needs (goals), interrelationships (dependencies), relationships with technology, alternative requirements, and tradeoffs amongst alternatives
Example Application: Strategic Requirements Analysis for Kids Help Phone

- Kids Help Phone (KHP) is a not-for-profit organization which provides counseling for Canadian children and youth.
- Traditionally, KHP has provided counseling via phone.
- As new technology is introduced, KHP wanted to go where the kids are: the web.
- How can counseling services be effectively provided on-line?
- How can the organization continue to ensure:
  - Anonymity?
  - Confidentiality?
  - Quality of Service?

Easterbrook, Yu, Aranda, Horkoff, Strategic Requirements Analysis for Kids Help Phone
Example Application: Security Requirements of a WiFi-based Navigation System

- In a WiFi-based navigation system, users navigate inside buildings using WiFi access points.
- The system could use existing WiFi access points or could install new access points.
- Using existing access points saves money.

Security issues: WiFi access points may be switched off.

Golnaz Elahi, Eric Yu, "Trust Trade-off Analysis for Security Requirements Engineering"
Example Application: “Greening” of ICSE Conference

- ICSE’09 wanted to “go green”, cutting down its eco footprint
- The conference must balance this goal with other factors affecting overall conference success, including:
  - Quality program, satisfied attendees, quality venue, good keynotes, positive relationship with sponsors, financial success, quality workshops, involvement of industry,...
- How can we reason over and make tradeoffs between sustainability and other goals?
Goal-Oriented Requirements Engineering

- GORE aim to capture both social and technical aspects of computer systems.

- In GORE, we want to capture:
  - Agents
  - Goals of agents
  - Dependencies between agents
  - Relationships between agents
  - Alternative solutions
  - Relationships between goals
  - Goal satisfaction

- We typically capture these aspects using graphical models.
Example Goal Modeling Framework: i* (Distributed Intentionality)

- i* is divided into two types of diagrams

- **Strategic Dependency (SD) Diagram**
  - Who is involved (technical and social actors)?
  - What do they need from each other (dependencies)?
  - What is the nature of their dependencies?
    - Achieve a goal?  Precisely defined?
    - Perform a task?
    - Provide a thing/entity?

- **Strategic Rational (SR) Diagram**
  - “Opens-up” each actor
  - Provides the “how” and “why” for dependencies
  - Goal refinement
  - Goal alternatives
  - Explores trade offs
i* Strategic Dependency Diagram (1)

- **Actors: General type**
  - Agent: software or social agent:
    - E.g. Counseling System, ICSE, Web Service, KHP
  - Role: collection of responsibilities
    - E.g. Client, Kid, Counselor, PC Chair
  - Position: collection of roles
    - E.g. Counseling Manager

- **Actor Associations:**
  - Plays, is-a, occupies, ins, is part-of

- These concepts can be used to draw actor association diagrams
Strategic Dependency Relationship

I want
...

Car Be Repaired

I can
...

Actor A

Actor B
Goal Dependency: I want you to achieve my goal, I don’t care how

Task Dependency: I want you to achieve this task, in an agreed upon way

Resource Dependency: I want you to provide this thing (entity)

Softgoal Dependency: I want you to achieve my goal, which is fuzzy, not clear-cut
Strategic Dependency (SD) Example: KHP

- **KHP**
  - Help As Many Kids as Possible
  - High Quality Counselling
  - Provide counseling via text message
  - Provide counseling via Cyber Café/Portal/Chat Room

- **Text Messaging Service**
- **Cyber Café/Portal/Chat Room Service**
- **Kids and Youth**
- **Counsellors**
SD Example: WiFi-based Navigation System
SD Example: “Greening” of ICSE Conference
i* Strategic Rationale Diagrams

- Actor boundaries
- Goals, Softgoals, Tasks, Resources
- Dependencies (as before)
- Decomposition (AND), Means-Ends (OR)

- Contribution: Make, Help, Hurt, Break, Unknown
What are the goals of KHP?
What are the relationships between the goals?
What are the alternatives?
How can these goals be satisfied?
What are the negative consequences?
Who do we depend on?
For what?
How?
SR Example: Wifi (high-level overview)
SR Example: ICSE Greening
There are several different approaches to goal-oriented modeling:

- **KAOS** (Knowledge Acquisition in autOmated Specification of software systems) *(Dardenne, A., Lamsweerde, VAN, & Fickas, S. (1993))*
  - Formal modelling of functional and non-functional requirements
  - Focus on NFR graphs, softgoals
- **i* Framework** (Distributed Intentionality) *(Yu, E. (1997))*
  - Added actors and dependencies
- **GRL** (Goal-Oriented Requirements Language) *(Amyot, D. (2003))*
  - Simplified i* linked to Use Case Maps
  - i* + agent-oriented methodology
- **Techne** *(Jureta, I. J., Borgida, A., Ernst, N. A., & Mylopoulos, J. (2010))*
  - Operationalized softgoals with quality constraints, added domain assumptions

Examples in this presentation have used i*
Many More Motivating Examples...

- **Air Traffic Control**
  - Lockerbie (City University London), Bush (NATS, UK), Maiden (City University London), Blom, Everdij (National Aerospace Laboratory (NLR), The Netherlands)
  - Paja, Dalpiaz, Giorgini (University of Trento, Italy), Paul (Thales Research and Technology, France), Meland (SINTEF, Norway)

- **Agile Adoption in Telecommunications**
  - Chiniforooshan, Yu (University of Toronto), Annosi (Ericsson Research Italy)

- **Civil Construction**
  - Alencar (Dep. Eletrônica e Sistemas), Castro (Centro de Informática), Menezes (Dep. Engenharia Civil, Universidade Federal de Pernambuco, Brazil), Silva, Santos (Centro de Informática)

- **Adverse Event Management in Healthcare**
  - Ahmadi Behnam and Daniel Amyot (University of Ottawa), Forster (The Ottawa Hospital)

- ... From the iStar Showcase’11:
Benefits of Goal Modeling

- Elicit stakeholder needs
- Facilitating cognitive understanding of stakeholder needs, dependencies, etc.
- Communication between and among stakeholders and analysts
- Shared understanding
- Making explicit what was implicit (goals, softgoals, dependencies)
- Capturing alternative requirements and solutions
- Selecting alternative solutions, trade off analysis
- ...

Goal-Oriented Requirements Engineering
J. Horkoff
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Many existing approaches for analyzing goal models

- Forward and backward satisfaction propagation: (Giorgini et al., 2004), (Amyot et al., 2010), (Letier & van Lamsweerde, 2004)...
- Metrics: (Franch, 2006)...
- Planning: (Bryl et al., 2007)...
- Simulation: (Gans et al., 2004)...
- Model Checking: (Fuxman et al., 2004)...

See Horkoff & Yu 2011, 2012 for surveys and comparison

We pick an example approach for illustration: qualitative, interactive analysis, Horkoff & Yu (2009, 2010)

Use qualitative labels to represent degree of satisfaction

Propagate labels throughout the model using propagation rules

Use human judgment to resolve conflicts
Qualitative, Interactive Forward Satisfaction Analysis

Evaluation based on an analysis question:

- If the Organization implements Chat Room, but not Text Messaging, what effect will this have on goals?

Place Initial Labels reflecting Analysis Question

Goal - Oriented Requirements Engineering  J. Horkoff

Propagate labels

Resolve labels

Iterate on the above steps until all labels have been propagated

Analyze result

Legend

- Satisfied
- Partially Satisfied
- Conflict
- Partially Denied
- Denied

Human Intervention

Immediacy

Receives the following Labels:

- Partially satisfied from Chat Room
- Partially satisfied from Text Messaging

Select Label…

Select partially satisfied
Capturing Uncertainty in Goal Models

- In RE, common to uncover uncertainty over model structure
- Use the MAVO formal uncertainty framework to capture uncertainty in GM

Business Intelligence Modeling

- Business Intelligence analyzes and displays business data, allowing businesses to monitor and strategize.
- We raise the level of abstraction of BI systems via a modeling language using familiar business concepts.

Adaptation and Evolution

- Many approaches use goal models as part of requirements-aware runtime monitoring, adaptation, and evolution.

- Requirements specifications represented as goal models (Techne foundation);
- Awareness reqs: “Goal 'Find a suitable room' should never fail / should have 90% success”;
- Parameters for reconfiguration (examples):
  - OR-refinements / variation points (VP2);
  - Control variables (RfM = Rooms for Meetings);
Run-time Analysis

- Goal models are not suited as is for run-time analysis:
  - They are defined in terms of goal classes
  - Don’t consider behavior or multiple instances
- We add behavior information to create Runtime Goal Models, then use runtime traces to create Runtime Goal Instances
Many approaches take a goal-oriented perspective on software security analysis.

For example, STS-ml is a goal-oriented language focusing on commitments, delegations, documents, and security requirements.

Analysis finds security requirements conflicts.

Alignment & Evolution

- Approaches aim to use goal-oriented languages to align social-technical system levels: business processes, software, infrastructure.
- Inspired by Zave & Jackson requirements formalization: S, D |→ R
- Li, Mylopoulos, Multi-layer Security Requirement Model, University of Trento, Thesis in progress.
- Alignment work with an emphasis on security alignment: Salnitri, Dalpiaz, Giorgini, Aligning Service-Oriented Architectures with Security Requirements In: OTM 12.
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Community & Events

- iStar Workshop
  - iStar’13 co-located with CAiSE’13, June 17\textsuperscript{th}-18\textsuperscript{th}, Valencia, Spain
  - \url{http://www.cin.ufpe.br/~istar13/}

- RIGiM (Requirements, Intentions, and Goals in Conceptual Modeling)
  - RIGiM’13 co-located with ER’13, November, Hong Kong
  - \url{https://sites.google.com/site/rigimworkshop13/}

- iStar Showcase
  - Co-located with RE’13, July, Rio de Janeiro?

- i* Wiki:
  - \url{http://istar.rwth-aachen.de/tiki-index.php}

- Incomplete i*-related publication list:
  - \url{http://istar.rwth-aachen.de/tiki-index.php?page_ref_id=4}

- i* Linked-in group: \url{http://www.linkedin.com/groups/istar-modeling}

- i* Citeulike: \url{http://www.citeulike.org/groupfunc/14571/home}
Tool Support

- See [http://istar.rwth-aachen.de/tiki-index.php?page=i%2A+Tools](http://istar.rwth-aachen.de/tiki-index.php?page=i%2A+Tools) for a list of available i*-related tools, for example:
  - OME, OpenOME, GR-Tool, ST-Tool, jUCMNav, Adoxx-istar, IStar Tool, the RE-Tools, STS-Tool, CSRML Tool, BIM-Tool, TAGOOOn Tool, ...

- Tool fair as part of iStar’11 and iStar’13

- Existing effort to introduce a common interchange language, iStarML: [http://www.upc.edu/gessi/istarml/](http://www.upc.edu/gessi/istarml/)

- Current effort at the University of Trento to create an online goal-oriented tool development community to support code-sharing and discussion
Challenges & Open Topics

- Scalability
  - Modularity
- Usability
  - Model validation
  - Stakeholder comprehension
- Alignment with existing RE and SE models/methods/languages
- Standardization (?)
  - Language
  - Tools
- Industry adoption
Conclusions

- Goal-oriented requirements engineering emphasizes the social and intentional aspects of system development
  - Explicitly address users goals
  - Who? How? Why?
- Several approaches/frameworks to goal modeling
- Many approaches for goal analysis
- Many extensions/applications
- Active community
- Several challenges and open issues
  - More work to be done!
References (1)

Presentation Sources:
- E. Yu: Social Modeling and i* - Themes and Variations. Seminar presented at Tilburg University, The Netherlands, June 9, 2009
- J. Horkoff, G. Elahi, Goal-Oriented Requirements Engineering Languages and Applications, Lecture, University of York, Toronto, CA

Case Studies:
- S. Easterbrook (PI), E. Yu (PI), J. Aranda, J. Horkoff, M. Strohmaier, Y. Fan, M. Leica, and R. Abdul Qadir:
  - Strategic Requirements Analysis for Kids Help Phone. U of T DCS Undergraduate Open House.
References (2)

GORE Frameworks


References (3)

- **GORE Analysis**

- **Business Intelligence**

- **Uncertainty**
References (4)

- **Adaptation & Evolution**
  - Souza V., Lapouchnian A. and Mylopoulos J., Requirements-Driven Qualitative Adaptation In: 20th International Conference on Cooperative Information Systems (CoopIS’12)

- **Run-time Analysis**
References (4)

- **Security**
  - [http://www.sts-tool.eu/](http://www.sts-tool.eu/)

- **Alignment**
  - Tong Li, John Mylopoulos, Multi-layer Security Requirement Model, University of Trento, Thesis in progress
  - Salnitri M., Dalpiaz F. and Giorgini P., Aligning Service-Oriented Architectures with Security Requirements In: OTM 12

Thank you!

Questions?

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