MODELING AND REASONING ABOUT CONTEXTUAL REQUIREMENTS

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Some requirements aren’t absolute, but context dependent:

- Context stimulates a requirement
  - It is humid inside → fresh air is required
- Context enables an alternative to meet a requirement
  - It is sunny and not windy outside → windows can be opened
- Context influences the quality of each alternative
  - He is sleeping → opening windows violates his privacy/comfort

Meeting requirements leads to changes in context.
- Opening the windows → opened windows and high light level
**MOTIVATION.**

- Most RE presumes uniform, not varying, contexts.
- In emerging computing, like UbiCom, PerCom, AmI, this assumption is no longer valid.

**Why Context with Goals?**

- Context influences human intentions & choices **first**.
- Software has to **reflect** human adaptation to context.

**Example:**
- if a context like "tourist has not had lunch yet and it is around lunch hour" holds
- the tour guide will try to reach a goal like "find a place for tourist to eat".
- Moreover, the context "tourist is vegetarian" will limit the restaurants from which the guide would choose.
CONTEXTUAL GOAL MODEL
ICAISE08, ER08, CAISE09 FORUM, EMMSAD09
CONTEXTUAL GOAL MODEL

• Context is the reification of the environment that is whatever provides a surrounding in which the system is to operate [Finkelstien STRAW’01].

• Adaptability is, essentially, selecting between variants.

• Associating each goal model variant & context is hard:
  – Exponential number of variants
  – Inability to understand variant at once.

• To bypass, we identify context on variation points in the goal model.
1. **Or-Decomposition**: each variant could require a valid context to be adoptable.

2. **Contribution**: contributions to softgoals are not absolutely positive or negative.

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- **C2**: product compliments another one the customer already has.
- **C3**: product is discountable & interesting to customer
- **C4**: product is free sampled & new to customer
- **C7**: staff is in the same room as customer
3. **Actors Dependency**: to depend on other, a certain context has to hold.

4. **Root goals**: context stimulates root goals

**C6**: staff is free, speaks a language common to customer, knows well the product, and close to customer

**C1**: enough time to promote, customer is not in a hurry, customer does not have the product
5. **And-Decomposition**: certain contexts make a subgoal/subtask in an And-decomposition needed.

6. **Means-end**: some tasks require a valid context to be adoptable in a means-end analysis.

- **C12**: customer is not around and can not be seen directly by the sales staff

- **C7**: the customer place is not noisy, the system is trained enough on the customer voice

- **C8**: customer has technology expertise and the used device has a touch screen
While Goal is a state of the world to reach; Context is a state of the world that is the case.

- We analyze goals to know what to do to reach them
- We analyze contexts to know what to monitor to verify them.
**CONTEXT ANALYSIS CONSTRUCTS**

- **Fact**: a predicate specifying a context, its truth value can be objectively computed.
  - E.g. $F_1$: customer never bought the product $[p]$ from the mall.

- **Statement**: .... can not be objectively computed.
  - E.g. $St_1$: Customer does not have the product $[p]$.

- **Help**: $F$: fact, $S$: statement. $help(F,S)$ iff $F \rightarrow S$.
  - E.g. $Help(F_1,St_1)$

- **Decomposition**: or/and of facts and statements.
  - E.g. customer is interested in product: (i) behaviorally or (ii) historically.
product \([p]\) is discountable and interesting for customer \([c]\)

- \([c]\) is interested in \([p]\)
- \([p]\) has to be finished
- \([p]\) historically interested of \([r]\)
- \([c]\) behaviorally interested in \([p]\)
- \([c]\) buys usually of \([p]\) category
- \([c]\) buys periodically \([p]\)
- \([c]\) holds \([p]\) recently for long time
- \([c]\) often comes to \([p]\) area
- \([c]\) holds of \([p]\)
- \([c]\) buys occasionally \([p]\)
- \([c]\) buys frequently \([p]\)
- \([c]\) holds \([p]\) recently for long time
- \([c]\) often comes to \([p]\) area

**Legend**

- Statement
- Fact
- Decomposition link
- Help link

**C3**

**MC3**

- Customer
  - Touched
  - Bought
  - Is At
  - Position
  - Mall
  - Contains
  - Product
  - Area
  - Category
  - Region

- Mall
  - has
  - contains
  - +quantity

- Store
  - located_at
  - belongs_to
• For each goal model variant:
  – **Stimulating context**: the conjunction of contexts at the Root goal and And-decompositions.
    • tourist is hungry
  – **Required context**: the conjunction of contexts at Or-decomposition, Means-End, and Delegation.
    • there is a close restaurant that accepts tourist credit card
  – **Quality contexts**: for each (variant, SG contribution).
    • the restaurant is close enough.
OVERALL
REASONING ABOUT CONTEXTUAL GOAL MODEL
The context analysis hierarchy translated to Boolean formula of leaf facts as variables.
The contextual goal model into Datalog.
A prototype tool “RE-Context” has been implemented.
Up to now, we encode the model manually.
We developed reasoning to validate the context of each goal model variant:

- Relations (implication and contradictions) are specified between contexts (at whatever level of the context hierarchy).
- SAT solver is used to find a model for the conjunction of the Boolean formula expressing a context and the assumed relations.

Note: the compact form of goal model could naturally include variants with inconsistent contexts. i.e. not necessarily modeling errors, but indeed unadoptable.
EXPLAINING CONFLICTS

• We provide reasoning to detect conflicts and:
  – The goals behind them.
  – The context in which they happens.
  – The alternatives that can avoid us the conflict.
  – The conflicts that are Core where a resolution is critical.

• As an example: Water Conflict.
Given a context and a user prioritization, we derive a suitable goal model variant.

Prioritization is given over softgoals for two reasons:
- Bypassing the enumeration of goal model variants.
- Talking to stakeholder in their terms.
• **Core requirements** are system requisite that can’t be bargained on.

• Discovering them is useful for timing & budget constraints, and when flexibility & quality is not a main issue. I.e. when we need just a **Valid System**.

• The variants that, at certain context, have no alternatives are core.
  
  – We discover core variants. (actually, core groups!)
  – We process the groups to elicit variants for minimum costs.
### Example

<table>
<thead>
<tr>
<th>The non-core variant</th>
<th>The variants excluding the non-core variants</th>
<th>The core groups of variants</th>
<th>The cost relations</th>
<th>The min-cost core requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>NV1= {T6, T10}</td>
<td>V1= {T1, T3}</td>
<td>Core1= {V1, V2, V3, V4}</td>
<td>Cost(T1,30), Cost(T2,40), Cost(T3,60), Cost(T4,80), Cost(T5,25), Cost(T6,35), Cost(T7,50), Cost(T8,30), Cost(T9,50), Cost(T10,50), Cost(T11,30).</td>
<td>The variants to develop= {V2, V5, V6}</td>
</tr>
<tr>
<td>NV2= {T6, T11}</td>
<td>V2= {T1, T4}</td>
<td>Core2= {V5}</td>
<td>Include(T2, T1), Intersect(T3, T4, 40), Intersect (T3, T5, 20), Intersect (T4, T5, 20), Intersect (T4, T9, 30)</td>
<td>The tasks to develop= {T1, T4, T5, T7, T8, T9}</td>
</tr>
<tr>
<td></td>
<td>V3= {T2, T3}</td>
<td>Core3= {V6}</td>
<td>Cost 340 (development of all variants)</td>
<td>Costs= 215 (development of the core variants V2, V5, V6)</td>
</tr>
<tr>
<td></td>
<td>V4= {T2, T4}</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>V5= {T5, T8, T9}</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>V6= {T7, T8, T9}</td>
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</tbody>
</table>

- **T1:** prepare [p] brief simple information
- **T2:** prepare [p] detailed information
- **T3:** [p] info is presented to [v] via video
- **T4:** [v] info is presented to [v] interactively
- **T5:** [v] is alerted via ringing tone and SMS
- **T6:** send [s] a voice command
- **T7:** make a call through speakers in [s] room
- **T8:** show [v] picture
- **T9:** direct [s] to [v] place
- **T10:** make video call between [s] and [v]
- **T11:** make voice call between [s] and [v]
- **T12:** Staff Assistance System
- **T13:** G3: [v] gets info through [m] staff [s]
- **T14:** G1: visitor [v] gets informed about a piece of art [p] in museum [m]
- **T15:** G2: [v] gets info via his/her PDA
- **T16:** G4: [p] info suitable to [v] is prepared
- **T17:** C1: visitor [v] gets informed about a piece of art [p] in museum [m]
- **T18:** C2: visitor [v] gets informed about a piece of art [p] in museum [m]

The non-core variant

The variants excluding the non-core variants

The core groups of variants

The cost relations

The min-cost core requirements
AN INTEGRATED FRAMEWORK

Traceability of goals at the system level

Justifying features by stakeholder intentions and relating them to quality measures

Context influences what products to derive

Variability rationale at the system characteristics level

Clear problem structure that allows for more detailed analysis of the system level variability

Goal Models

Context influences the adoptability of goal satisfaction alternatives & their qualities.

Variability rationale at the intentional level and quality measures for assessment of variants

Clear problem structure that allows for more detailed analysis of the goal level variability

Feature Models

Problem Frames (PF)
USEFULNESS OF INTEGRATION
• Variability is that of human intentions and choices first.
• Context influences decisions at this level first.
• A Dynamic SPL has to reflect such adaptation to derive a contextualized product variant.
• We introduced the terms:
  – Online SPL Contextualization.
  – Offline SPL Contextualization.
  – Maintenance based on operation in multiple contexts.
• Lifelong Contextualization!!
  – “What are the requirements? Well, it depends on the context, but I do not know exactly how”.

• Viewpoints in Context Specification:
  – E.g., Tourist is interested in attending a cultural event if
    • the event conveys very new information
    • If the event is related to the tourist culture.

• Security Requirements in Varying Vontexts.
  – E.g., unless I am unconscious or far away from my city, no one but my private doctor can see my medical record without my permission.