Contextor: a Computational Model for Contextual Information

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Context for Ubicomp: no Consensus, but some Lessons

- Lesson1: Context can only be defined in relation to a purpose
  - As for us: Computational perception (user's implicit actions, environment sensing)
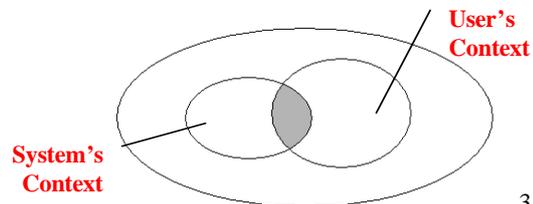
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1

Context for Ubicomp: no Consensus, but some Lessons

- Lesson1: Context can only be defined in relation to a purpose
  - As for us: Computational perception (user's implicit actions, environment sensing)

- Lesson 2: Context is an information space that serves interpretation
  - As for us: Interpretation by the system for serving users

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User's Context

System's Context

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Context for Ubicomp: no Consensus, but some Lessons

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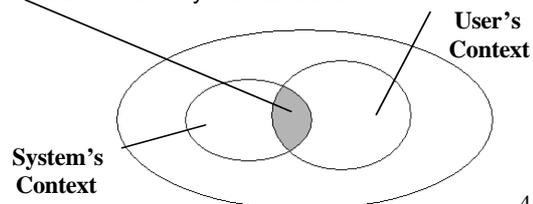 - As for us: Interpretation by the system for serving users

- Lesson 3: Context is an information space that is shared
  - As for us: Common ground between a system and a user

-
  -

User's Context

System's Context

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- Lesson1: Context can only be defined in relation to a purpose
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- Lesson 3: Context is an information space that is shared
  - As for us: Common ground between a system and a user

- Lesson 4: Context is an ever-ending information space: it evolves

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Outline

- Ontology for computational perception

- Computational model: contextor

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Ontology …

- Domain (world) = a network of states

S3 — S4
S2 — S3
S1 — S3
S4 — S6
S4 — S

Ontology …

- Domain (world) = a network of states linked by actions

a1 — S3 — a3 — S4
S2
S1 — a2
S4 — a3 — S6
S4 — a2 — S

Ontology …

- Domain (world) = a network of states linked by actions
- State = a predicate function over observables

$a1$ $S3$ $a3$ $S4$ $a3$ $\underline{S6}$

$\underline{S2}$ $a2$ $a2$ $\underline{S1}$

$\underline{S}$

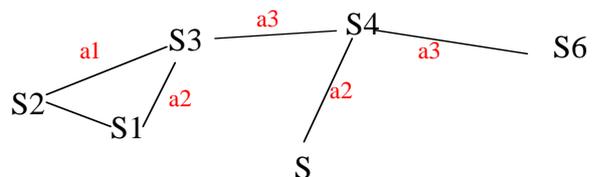$\underline{P(O_1, O_2, \ldots, O_n)}$
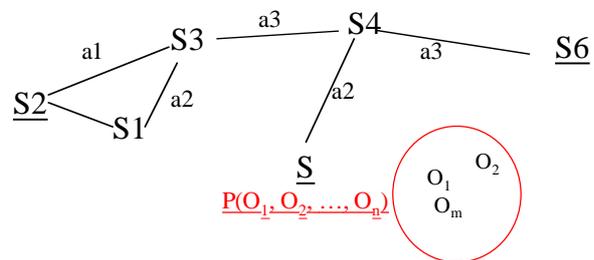
O_1 O_2 O_m

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Ontology …

- Domain (world) = a network of states linked by actions
- State = a predicate function over observables
- Goal state = a desired state

$a1$ $S3$ $a3$ $S4$ $a3$ $\underline{S6}$
Goal state

$S2$ $a2$ $a2$ $S1$

$\underline{S}$

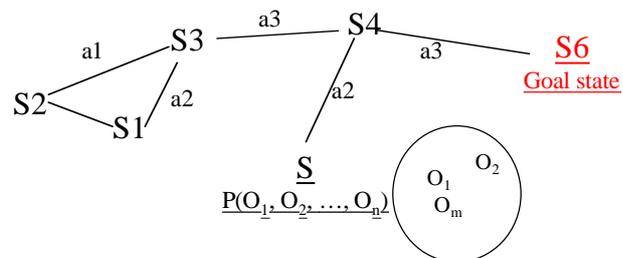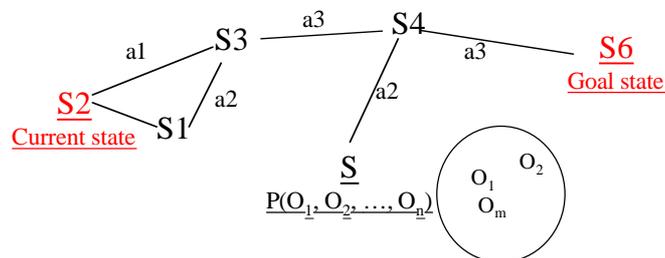$\underline{P(O_1, O_2, \ldots, O_n)}$

O_1 O_2 O_m

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Ontology …

- Domain (world) = a network of states linked by actions
- State = a predicate function over observables
- Goal state = a desired state
- Task = <current state, goal state>, i.e., no plan

$$a1 \quad S3 \xrightarrow{a3} S4 \xrightarrow{a3} S6$$

S2
Current state — S1 — a2

S4 — a2 — S

$\underline{S}$
$\underline{P(O_1, O_2, \ldots, O_n)}$

O_1 O_2
O_m

S6
Goal state

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Ontology …

- Domain (world) = a network of states linked by actions
- State = a predicate function over observables
- Goal state = a desired state
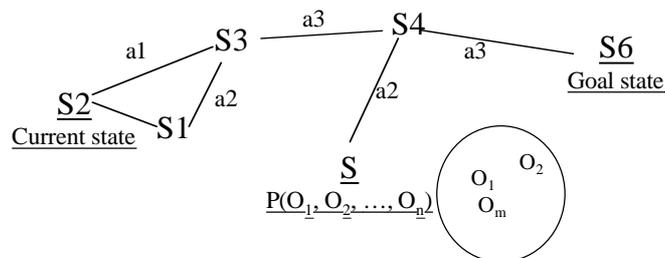- Task = <current state, goal state>, i.e., no plan
- Activity = <active tasks> = <current task, background tasks>

$$a1 \quad S3 \xrightarrow{a3} S4 \xrightarrow{a3} S6$$

S2
Current state — S1 — a2

S4 — a2 — S

$\underline{S}$
$\underline{P(O_1, O_2, \ldots, O_n)}$

O_1 O_2
O_m

S6
Goal state

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Ontology …

- Tasks involve entities (e.g., a table, pen, color)

<u>Entity</u>
<u>E1 Table</u>

<u>Entity</u>
<u>E2 Pen</u>

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Ontology …

- Tasks involve entities (e.g., a table, pen, color)
- Entity = a grouping of observables

O_k
O_n O_1
<u>Entity</u>
<u>E1 Table</u>

O_2
O_m O_1
<u>Entity</u>
<u>E2 Pen</u>

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Ontology …

- Tasks involve entities (e.g., a table, pen, color)
- Entity = a grouping of observables
- Entities may have a role = a function relative to a task that is satisfied by an entity, e.g., sitting surface

Role Sitting surface
{E1}

O_k
O_n O_l

Entity
E1 Table

Role pointer
{E2}

O_2
O_m O_1

Entity
E2 Pen

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Ontology …

- Tasks involve entities (e.g., a table, pen, color)
- Entity = a grouping of observables
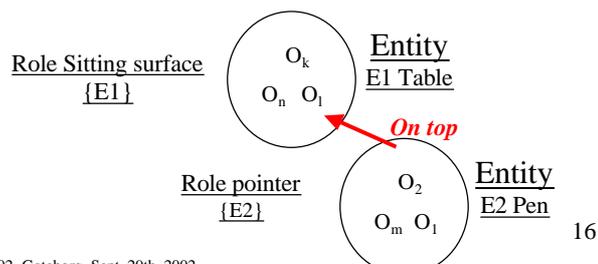- Entities may have a role = a function relative to a task that is satisfied by an entity, e.g., sitting surface
- Entities may have relations

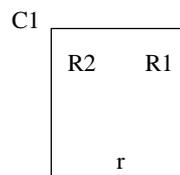Role Sitting surface
{E1}

O_k
O_n O_l

Entity
E1 Table

On top

Role pointer
{E2}

O_2
O_m O_1

Entity
E2 Pen

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Ontology…

- Context(U,T) = a set of roles and relations between entities for the performance of T by U

C1

```
R2     R1


    r
```

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Ontology…

- Context(U,T) = a set of roles and relations between entities for the performance of T by U
- Context change = the set of roles changes

C2

C1

```
R2     R1       New role       R2     R1

                                   R3
    r
                                    r
```

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Ontology…

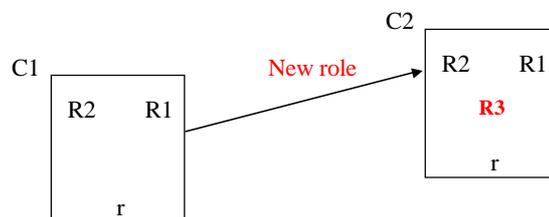- Context(U,T) = a set of roles and relations between entities for the performance of T by U
- Context change = the set of roles changes and/or the set of relations changes

C1

R2   R1

r

New role

C2

R2   R1

R3

r

New relation

C3

R2   R1

r'

r

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Ontology…

- Context(U,T) = a set of roles and relations between entities for the performance of T by U
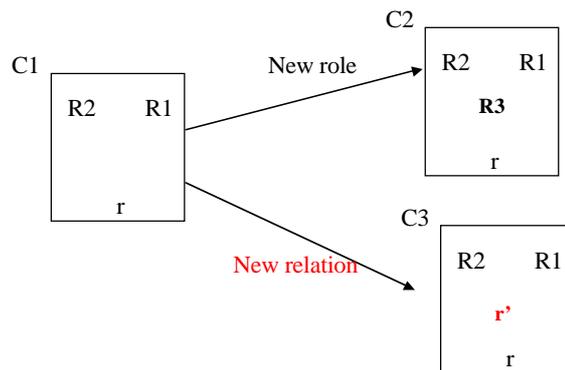- Context change = the set of roles changes and/or the set of relations changes
- Tasks and activities happen in a network of contexts

C1

R2   R1

r

C2

R2   R1

R3

r

C3

R2   R1

r'

r

20

Ontology…

- Context(U,T) = a set of roles and relations between entities for the performance of T by U
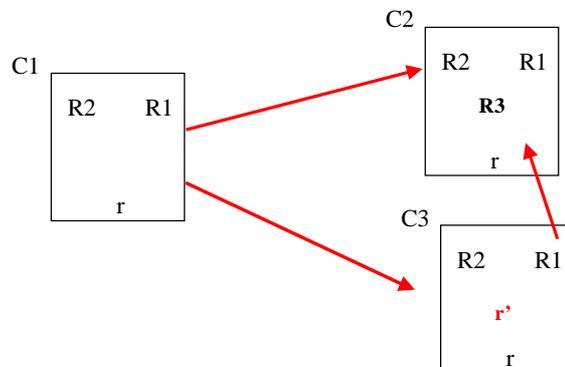- Context change = the set of roles changes and/or the set of relations changes
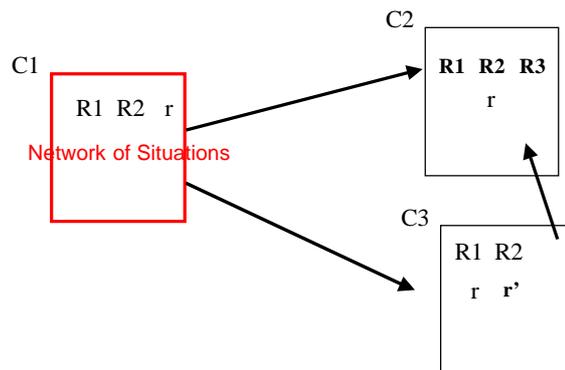- Tasks and activities happen in a network of contexts
- Context (U,T) = a network of situations that share the same set of Roles and Relations

C1

R1 R2 r

Network of Situations

C2

R1 R2 R3
r

C3

R1 R2
r   **r'**

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Ontology …

- Within a context, a situation is a configuration of
  - A set of entities
  - Assignments of roles to entities
  - Relations between these entities
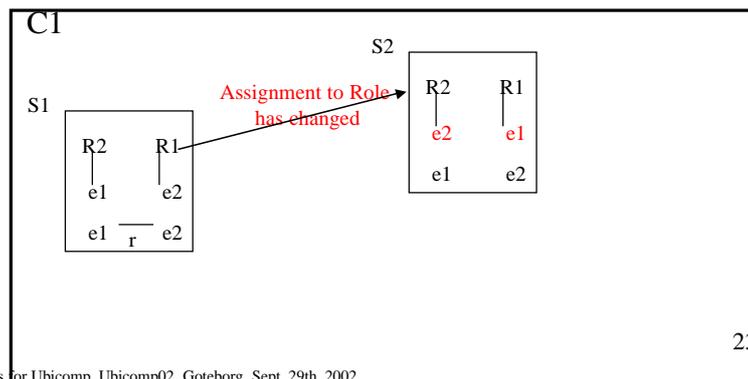
C1

S1

R2   R1
| |
e1   e2
e1   r   e2

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Ontology …

- Within a context, a situation changes when
  - assignments of entities to roles changes

C1

S1
R2   R1
e1   e2
e1 ─r─ e2

S2
R2   R1
e2   e1
e1   e2

Assignment to Role has changed

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Ontology …

- Within a context, a situation changes when
  - assignments of entities to roles changes
  - relations between the entities change

C1

S1
R2   R1
e1   e2
e1 ─r─ e2

S2
R2   R1
e2   e1
e1 ─r─ e2

Assignment to Role has changed

S3
R2   R1
e1   e2
e2 ─r─ e1

Relation has changed

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12
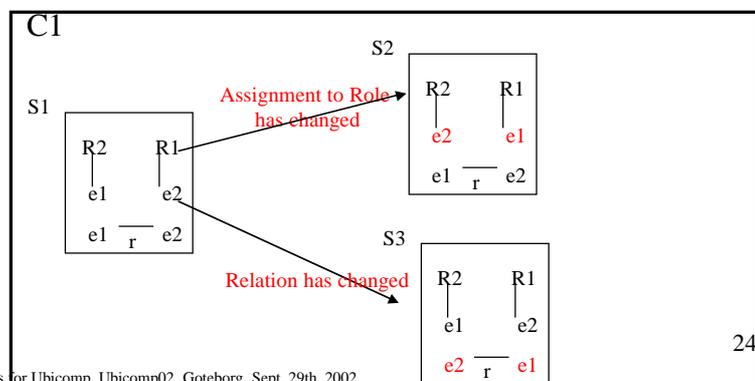
Ontology …
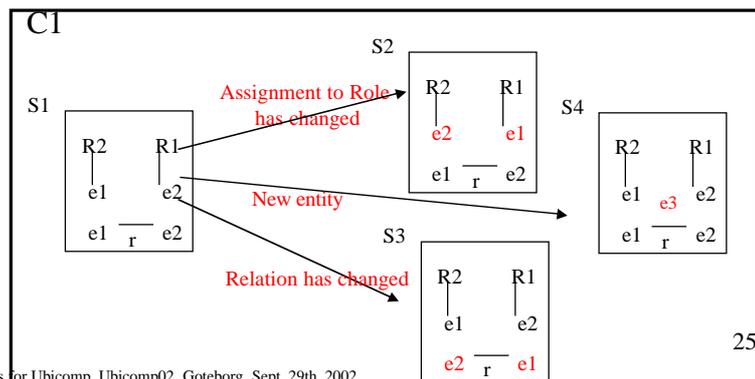
- Within a context, a situation changes when
  - assignments of entities to roles changes
  - relations between the entities change
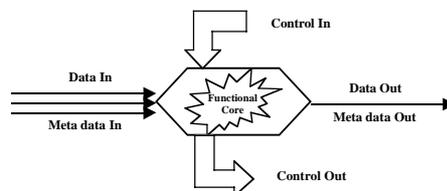 - The set of entities changes

C1

S1

R2   R1
e1   e2
e1   r   e2

Assignment to Role has changed

S2

R2   R1
e2   e1
e1   r   e2

New entity

S4

R2   R1
e1   e3   e2
e1   r   e2

Relation has changed

S3

R2   R1
e1   e2
e2   r   e1

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Computational model: the Contextor …

- ## A computational abstraction
  - Two functional facets
    - Transformation: Data (Type X) +meta-data -> Data (Type Y) +meta-data
    - Control: adaptation of behavior
  - Synchronous and asynchronous ports
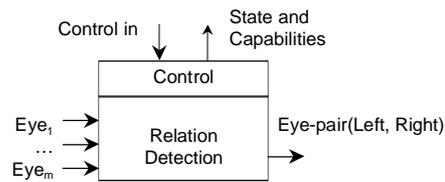
Control In

Data In

Meta data In

Functional Core

Data Out

Meta data Out

Control Out

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Computational model: the Contextor …

- Instantiation 1: data as observables

Control in → Control

State and capabilities

Color Image → Skin Color Detection → Skin Probability

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Computational model: the Contextor …

- Instantiation2: from Observables to Entity

Control in → Control

tate and apabilities

Probability Image → Grouping Detected Pixels → Blob, ID,x, y, s_x,

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Computational model: the Contextor …

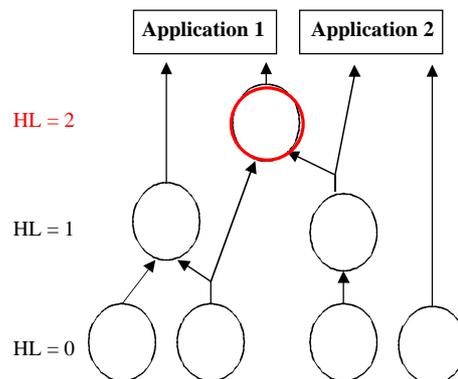- Instantiation3: from entities to relation between entities

Control in   State and Capabilities

Control

Eye_1
…
Eye_m

Relation Detection

Eye-pair(Left, Right)

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Contextors composition

- Data flow model
- Hierarchical levels (HL)
- Dependency chain

Application 1   Application 2

HL = 2

HL = 1

HL = 0

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Contextors: properties

- Reflexivity
  - Ability to describe its behavior
  - Ability tomodify its behavior

- Remanence
  - Ability to sleep, to be saved then to restart execution

- Context => federation of contextors

- New situation => reconfiguration of the contextors within the federation
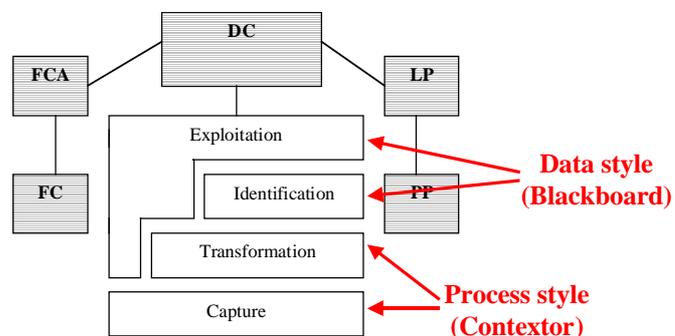
- New context => new federation of contextors

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Contextors: global architectural picture

- Extension of the ARCH model (D.Salber)

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