Adaptive Choreographies

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Choreographies

- Allow to describe the behavior of a distributed communicating system at the very abstract level
- Composed by interactions of the form a $\stackrel{o}{\rightarrow} b$
- Using different operators
  - Sequential composition ;
  - Parallel composition ||
  - Nondeterministic choice +
- There are approaches extending choreographies with additional information (data, recursion, ...)
- Very similar to global types in multiparty session types

Choreography projection

- Allow to automatically derive from a choreography the description of the behavior of each participant
- Nearer to the implementation
- Preserves the semantics: when interacting, the participants behave as specified by the choreography

Participants description

- Locations corresponding to participants, containing their code
- Basic operations: input $o@a$ and output $\bar{o}@a$
- Composed using
  - sequential composition ;
  - parallel composition |
  - nondeterministic choice +

Examples

- The projection of a $\xrightarrow{o} b$; b $\xrightarrow{o'} c$ is $[\bar{o}@b]_a \mid\mid [o@a; \overline{o'}@c]_b \mid\mid [o'@b]_c$
- The projection of a $\xrightarrow{o} b; c \xrightarrow{o'} d$ is $[\bar{o}@b]_a \mid\mid [o@a]_b \mid\mid [\overline{o'}@d]_c \mid\mid [o'@c]_d$
  - Not well-behaved
  - Syntactic connectedness conditions exist to avoid this problem
  - Choreographies can be transformed so to satisfy the conditions

Adaptation

- Systems should live for long periods of time in ever changing environments
- Users can change their minds
- The system should adapt to satisfy new requirements

Grey box adaptation

- Adaptation happens at runtime
- Adaptation details not known when the system has been designed or even started
- The system should provide an interface to interact with an adaptation middleware
- At runtime the adaptation middleware will send new code to the system

Adaptation and choreographies

- Lots of works on adaptation exist
- Not many formal approaches
- Very little guarantees on the properties of the system after adaptation takes place
  - Which parts of the behavior are changed and which are preserved?
  - Is it still safe?
- Using choreographies we can guarantee safe adaptation

Our approach, architecturally

- A system is obtained as projection of a choreography
- The system may run on its own
- The system may interact with an adaptation middleware
  - Composed by possibly distributed adaptation servers
  - Requires a dedicated interface from the application
- A single adaptation may involve many participants
  - Need for some coordination protocol

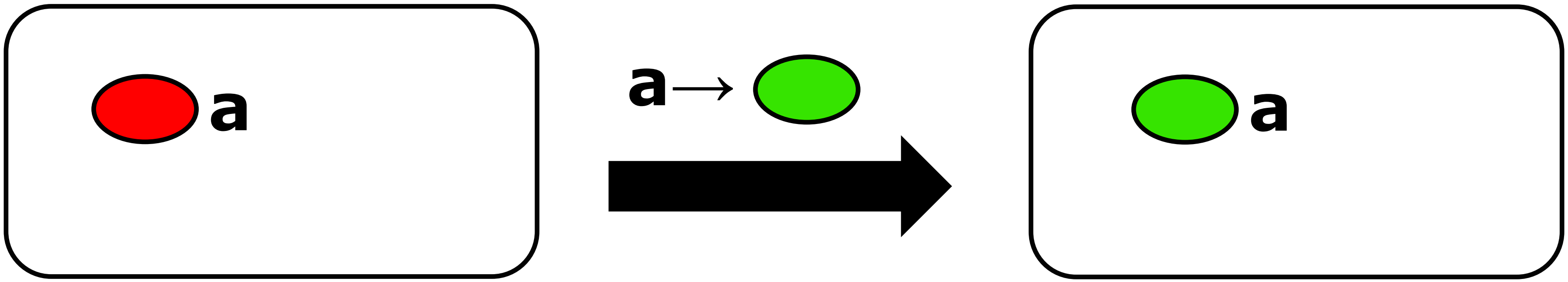
Adaptation rules

- The adaptation servers contain rules which can be applied to update the running system
  - Conditions checking whether adaptation is applicable/useful can be specified
  - Each rule may involve multiple participants
  - New rules can be added at any moment
- Application of a rule involves code mobility from the adaptation server to the system
- Rules can be added at any time + rules contain code $\rightarrow$ the system may not contain code to cope with every possible adaptation when it is started

Our approach, semantically

- Extend choreographies with adaptation scopes
  - Part of the choreography to which a rule may be applied
  - But the choreography does not specify which rule
- The system is executed together with a set of applicable rules (abstracting adaptation servers) and an environment
- Adaptation rules include
  - The new code for the scope
  - Information on when and where the rule can be applied
- Using projection we can derive the new code for each participant
- A coordination protocol is required to apply the updates

Our approach, graphically



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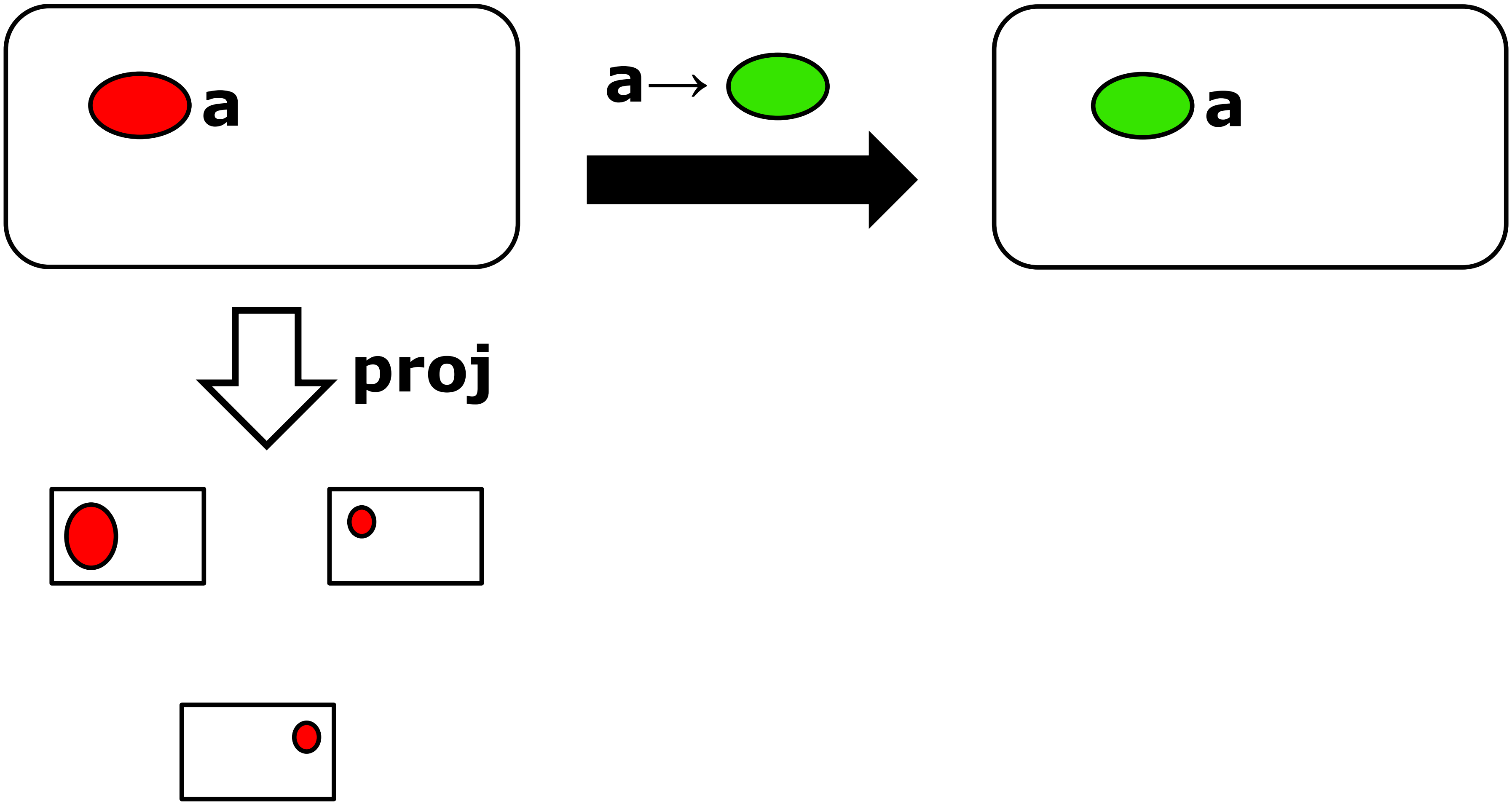
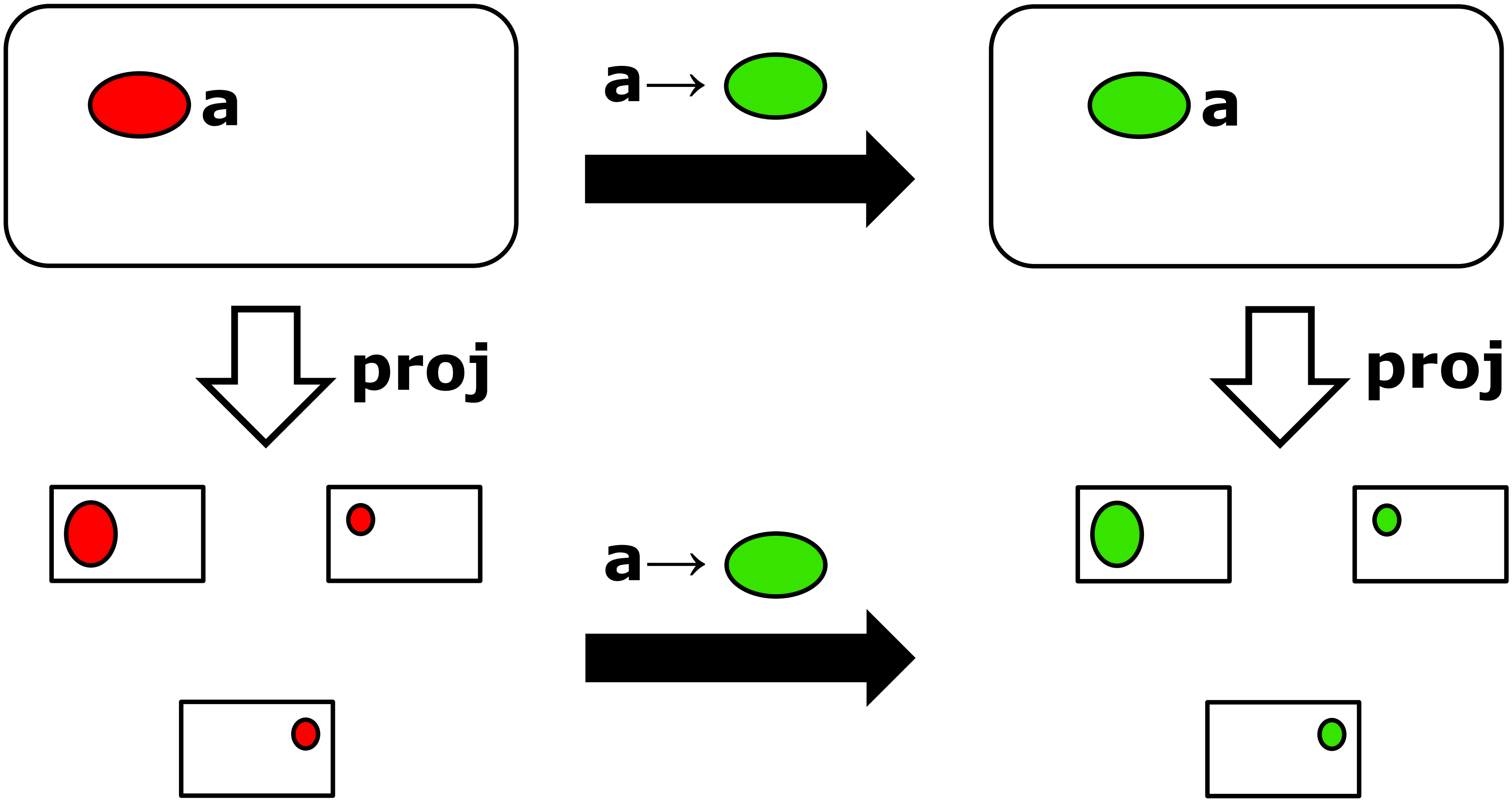


Our approach, graphically



Advantages of the approach

- The effect of adaptation at the choreography level is clearer
  - Abstract, global view
  - Good properties by construction
- Adaptation is applied to the running system
  - Projection allows to bridge the gap

Adaptation scopes

- An adaptation scope has the form $\{C, \Delta\}_{l,k}^{r}$
- C is the choreography to be executed if no adaptation is performed
- Δ is a set of non functional properties guarenteed by the current choreography
- r is the role leading the adaptation process
- l is a label of the scope
- k is a key ensuring the scope is uniquely identified

Adaptation rules

- An adaptation rule has the form $l, c \to C$
- l is the label of scopes the rule can be applied to
- c is an applicability condition
  - May involve non functional properties of the current scope and environment conditions
- C is the new choreography to be executed if adaptation succeeds

Projecting a scope

- Essentially homomorphic
  - On the leader we also keep the set of involved participants
  - On other roles, Δ is not needed
- Semantics of the leader
  - Check whether there is a rule targeting the scope whose applicability condition holds
  - If so, download the code for all the participants and send it to them
  - If not, tells the other participants that no adaptation is needed
- Semantics of other participants
  - Wait for instruction from the leader
  - If adaptation is needed, execute the new code
  - If not, execute the current code

Results

- A choreography and its projection have the same traces
  - Under all possible adaptations
  - With environments and sets of applicable rules that may change at any moment during the computation
- The adapted system is deadlock free by construction
- Note that we are adapting in a coordinated way a distributed system

Current and future work

- Going towards an implementation
  - Language with data, if-then-else and while
  - More at the level of choreographies according to Montesi & Carbone terminology
  - Projecting to Jolie
- Current choreographies can be seen as types for the new ones
- Which is the impact of adaptation on refinement?
- Different design choices on adaptation to be explored
  - When is adaptation applied?
  - Which applicability conditions are allowed?

End of talk

Thanks!

Questions?