Prototype Platforms for Distributed Agreements

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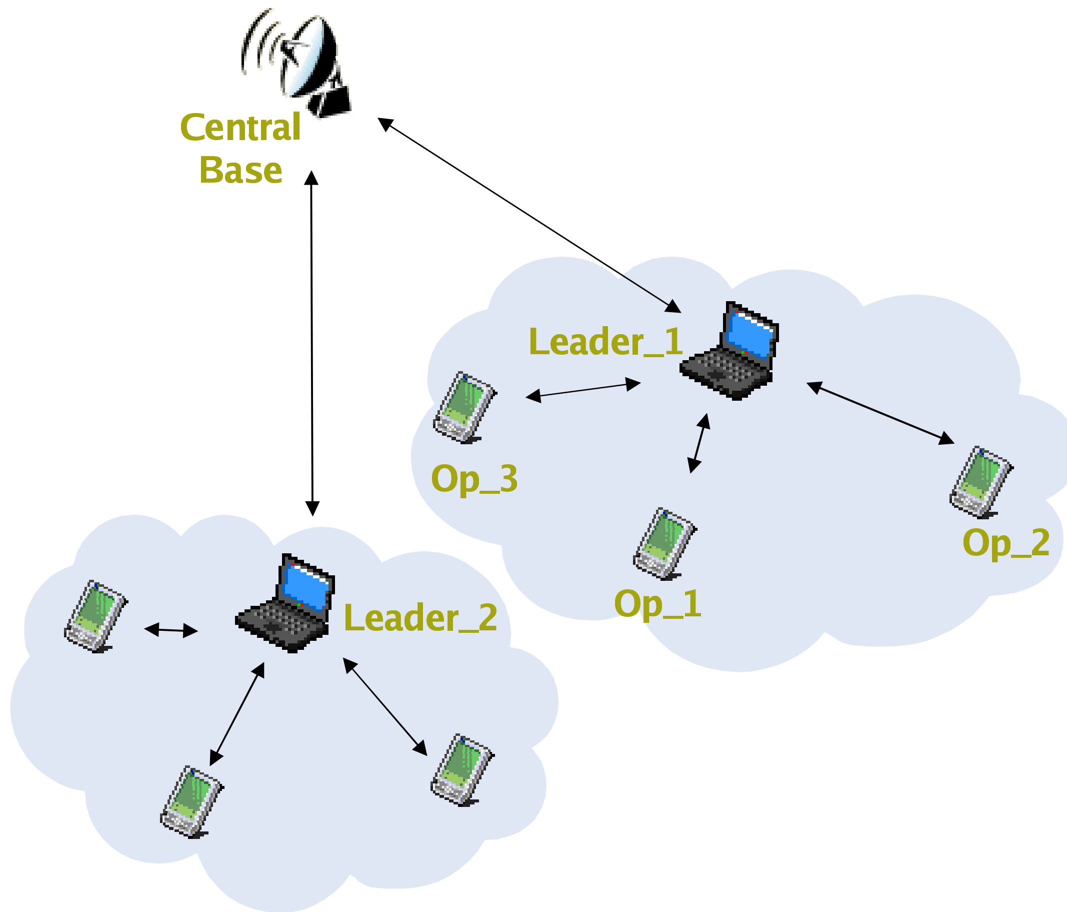
Motivation

- Orchestration of multi-party negotiations
  - Participants cannot be fixed statically
  - Participants have a partial view of the whole set of parties
- To develop a coordination pattern that exploits the D2PC protocol for orchestrating agreements
- To build a prototype application

Scenario: Rescue teams



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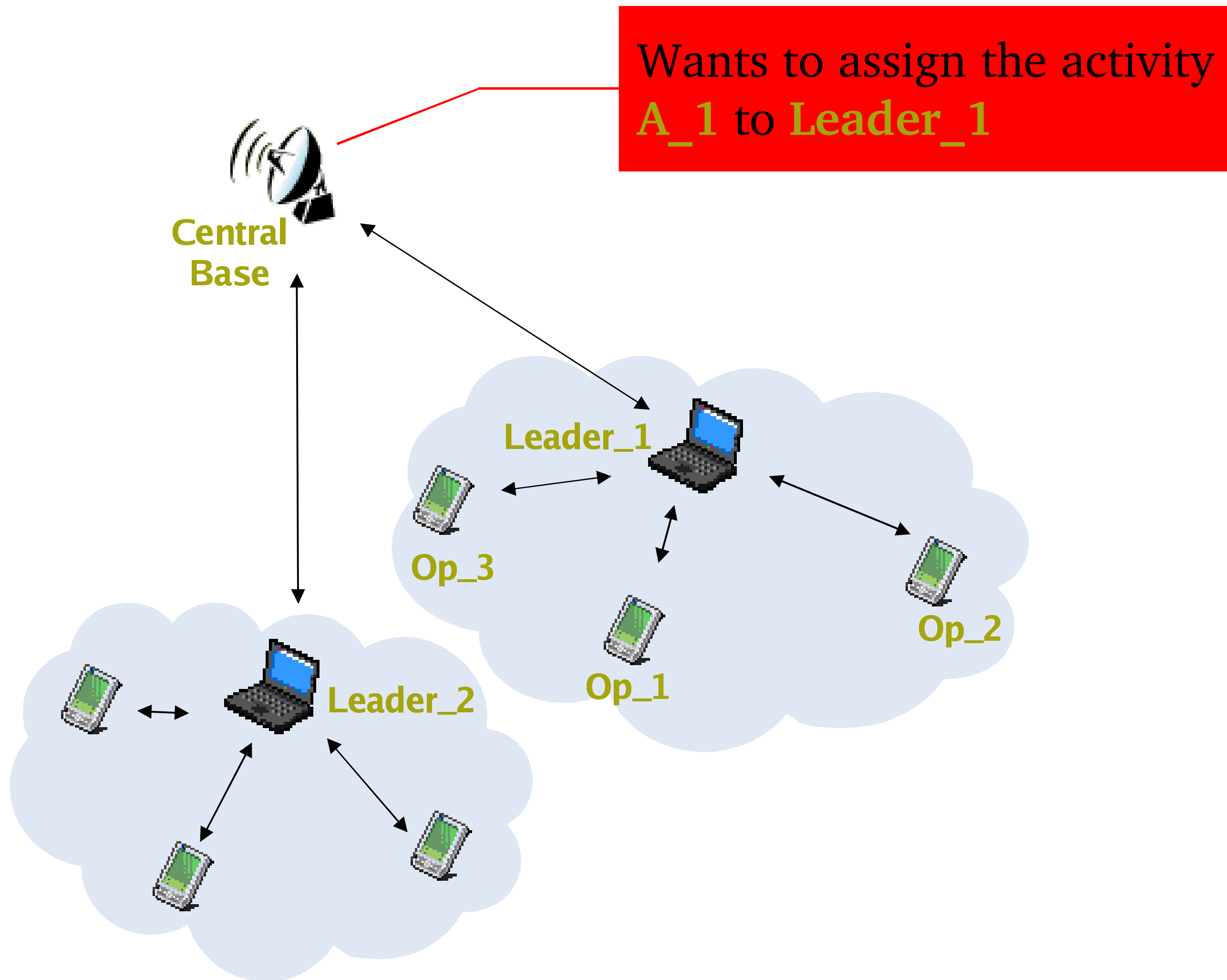

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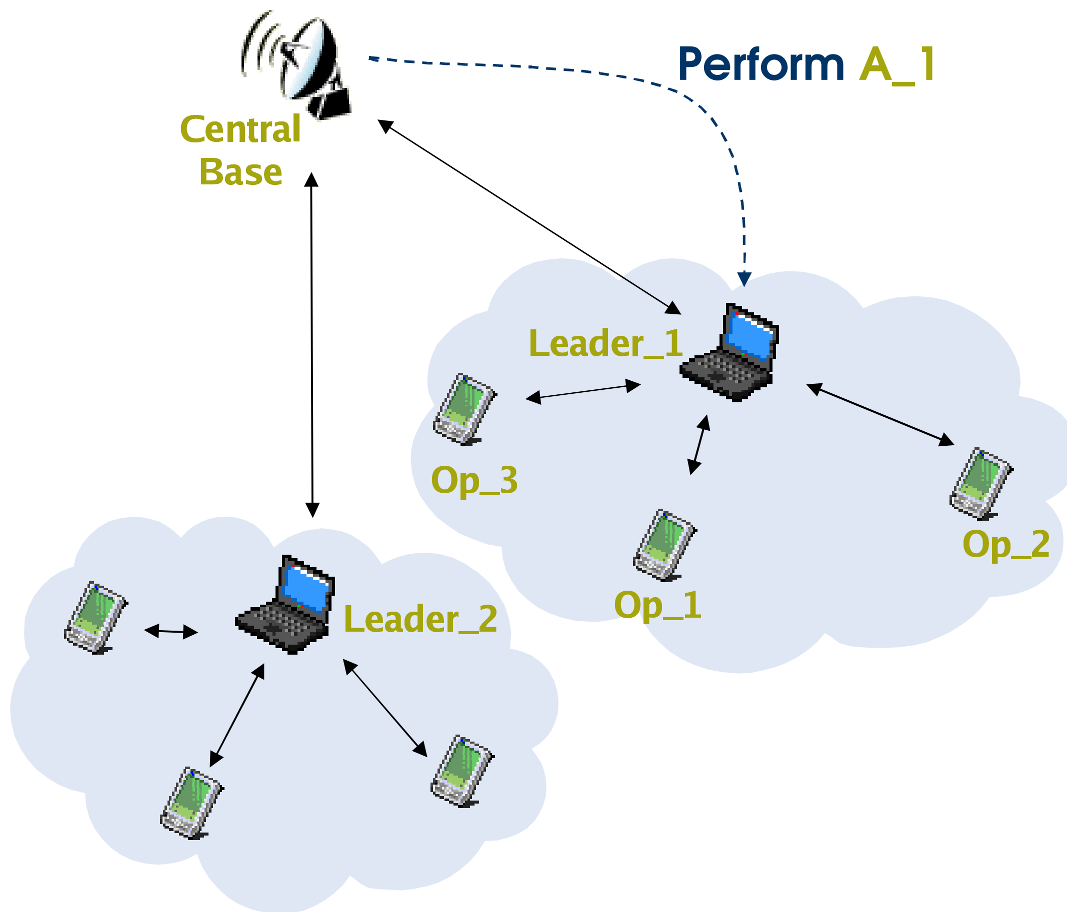

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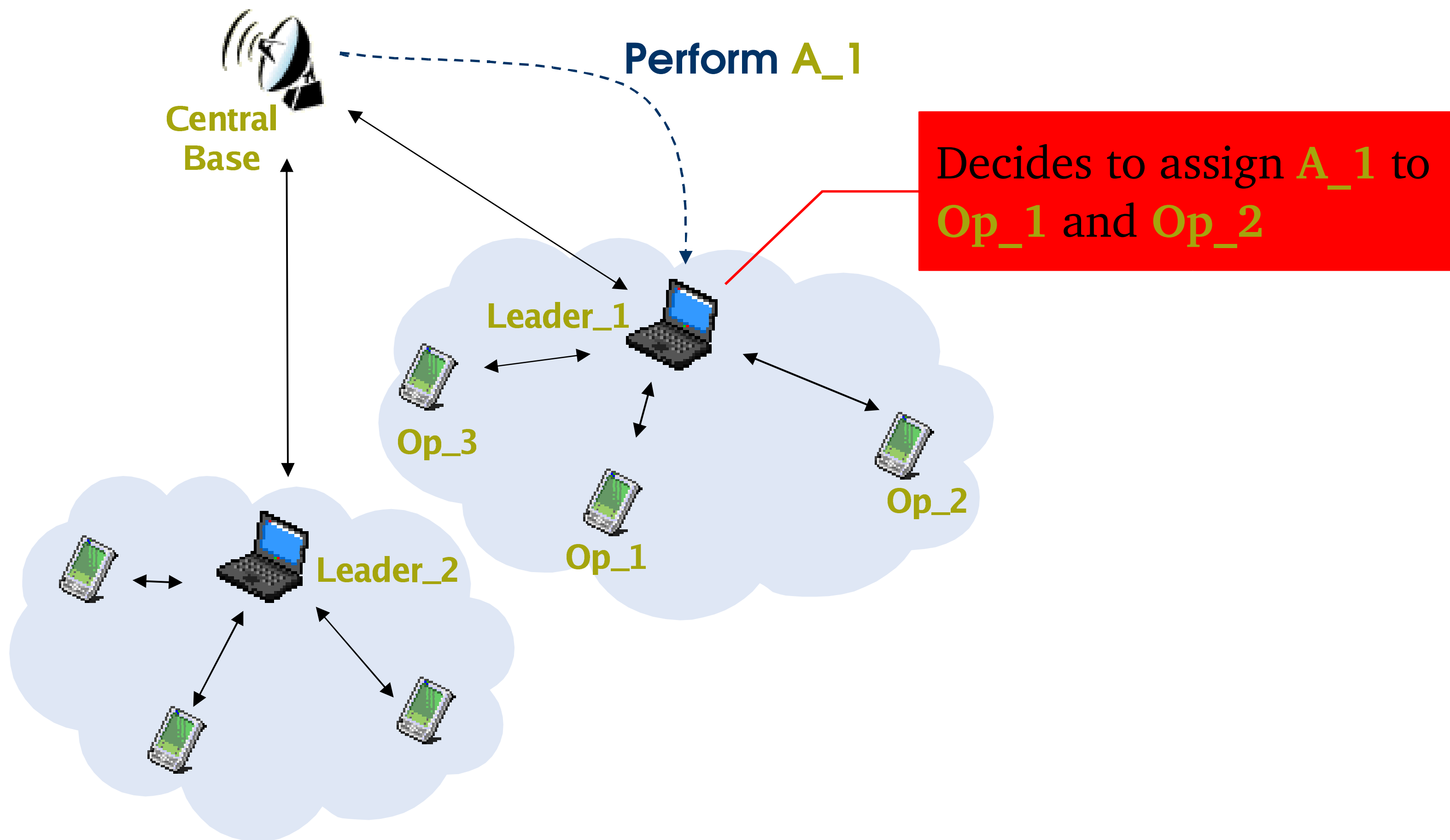

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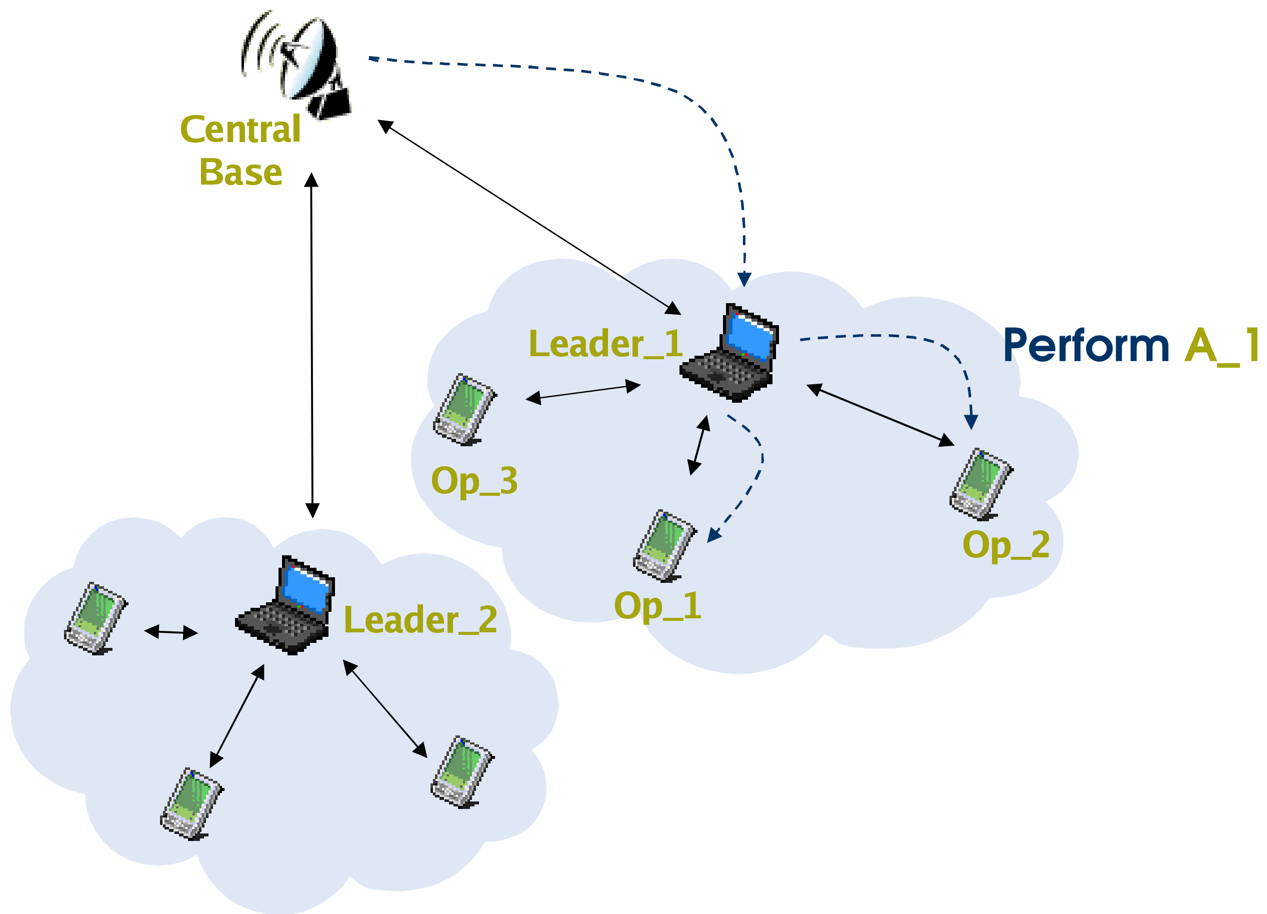

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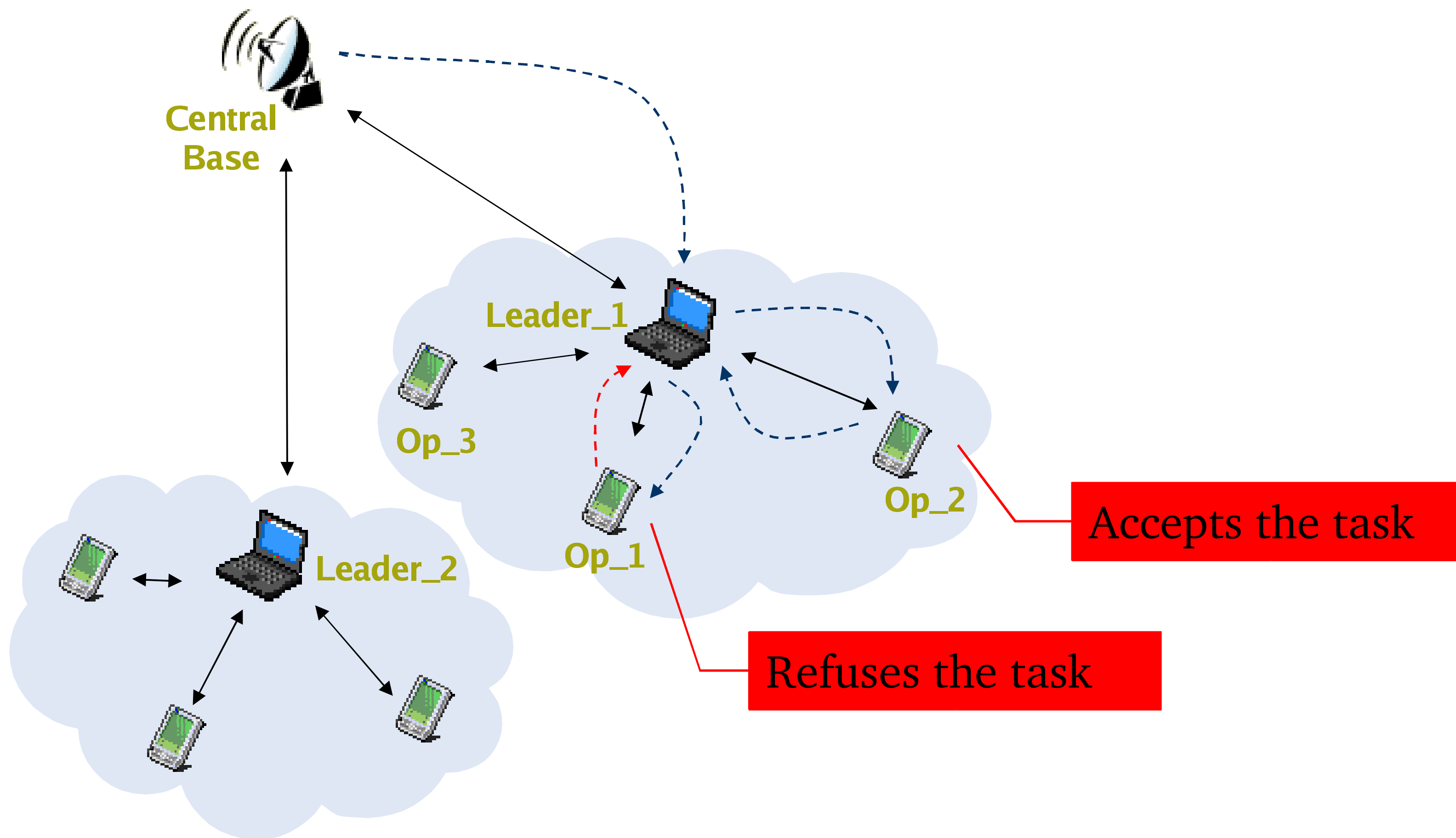

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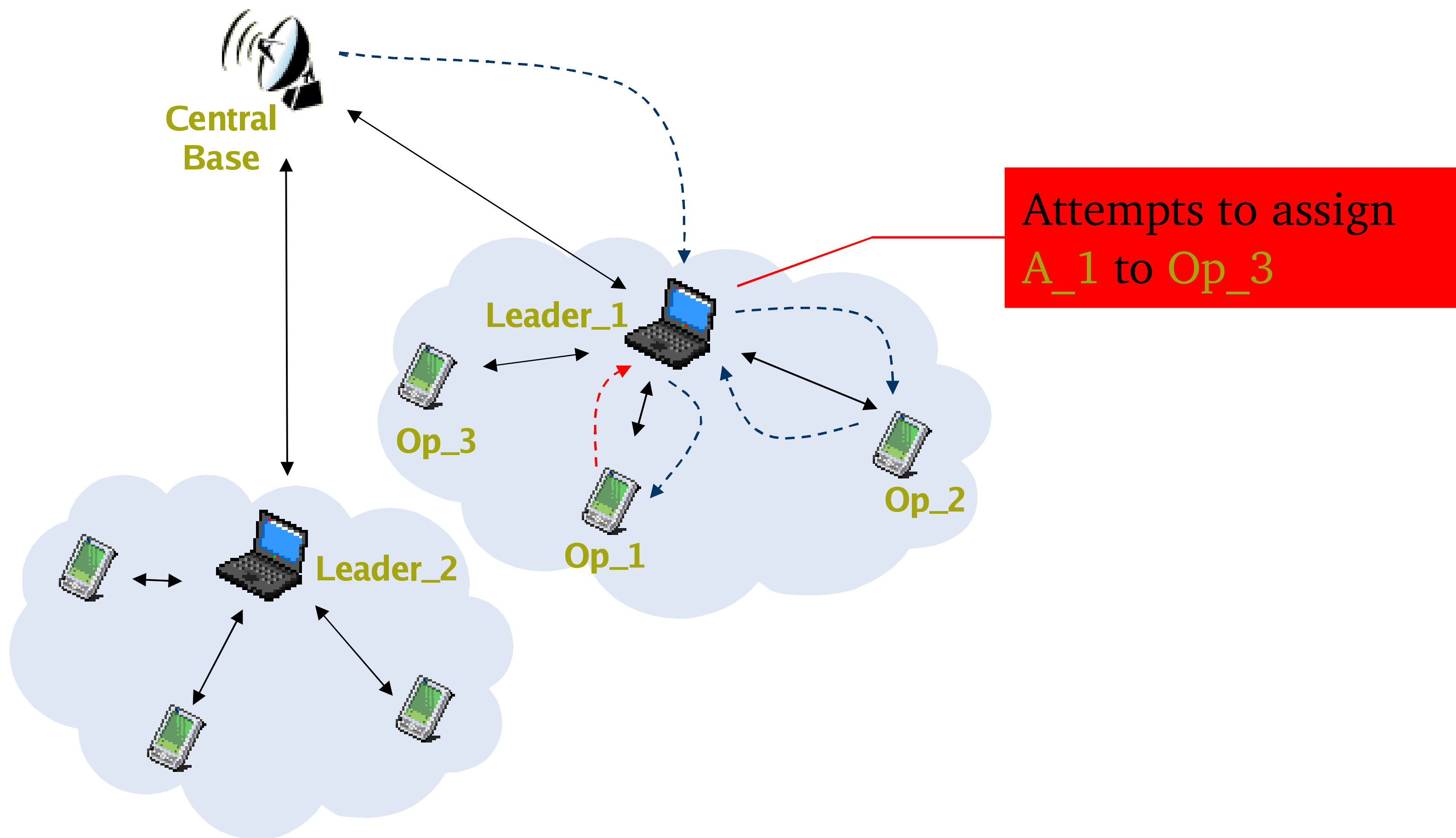

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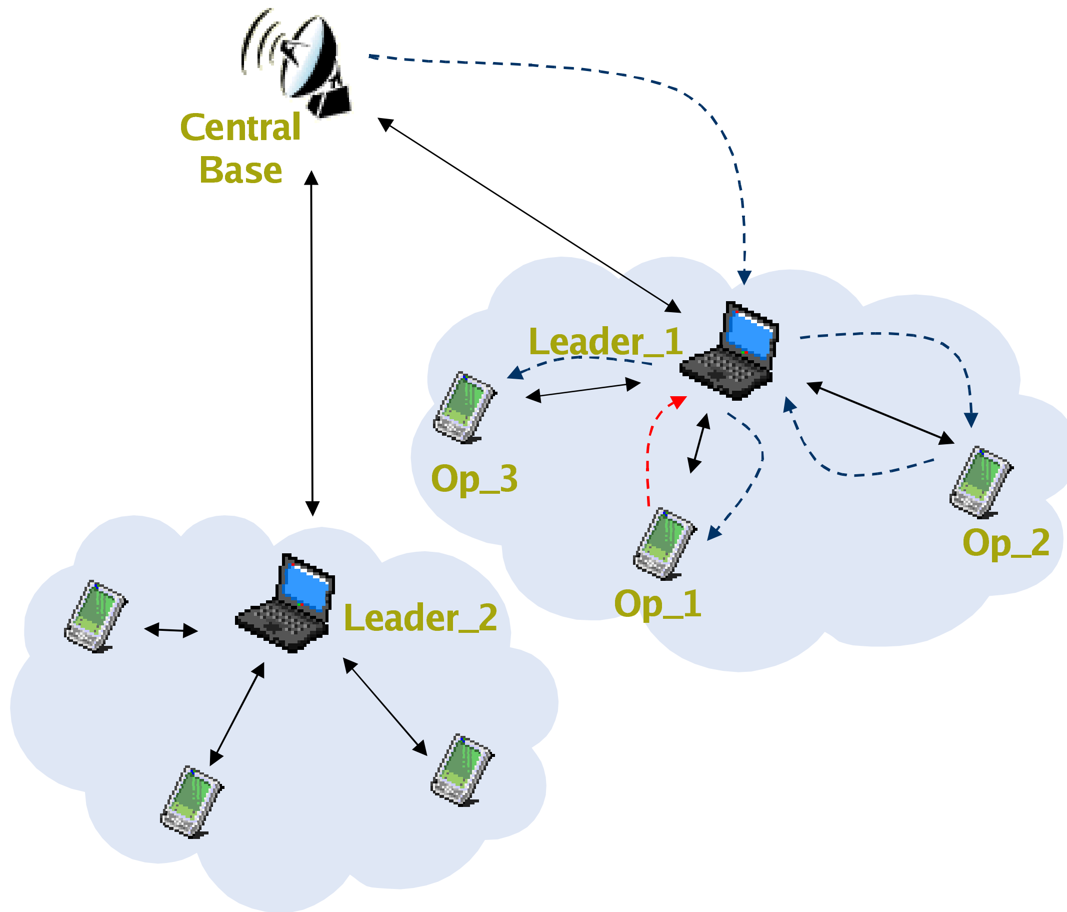

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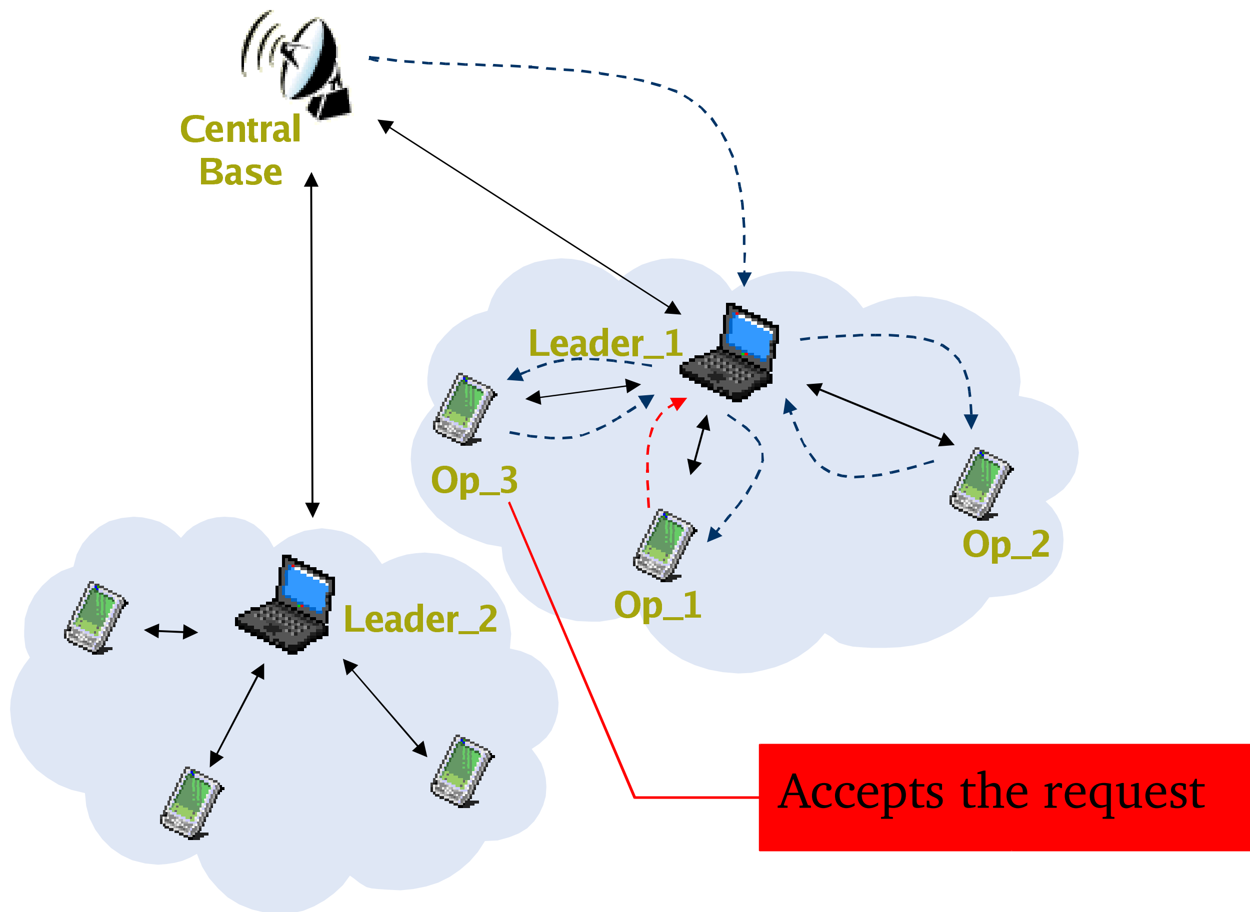

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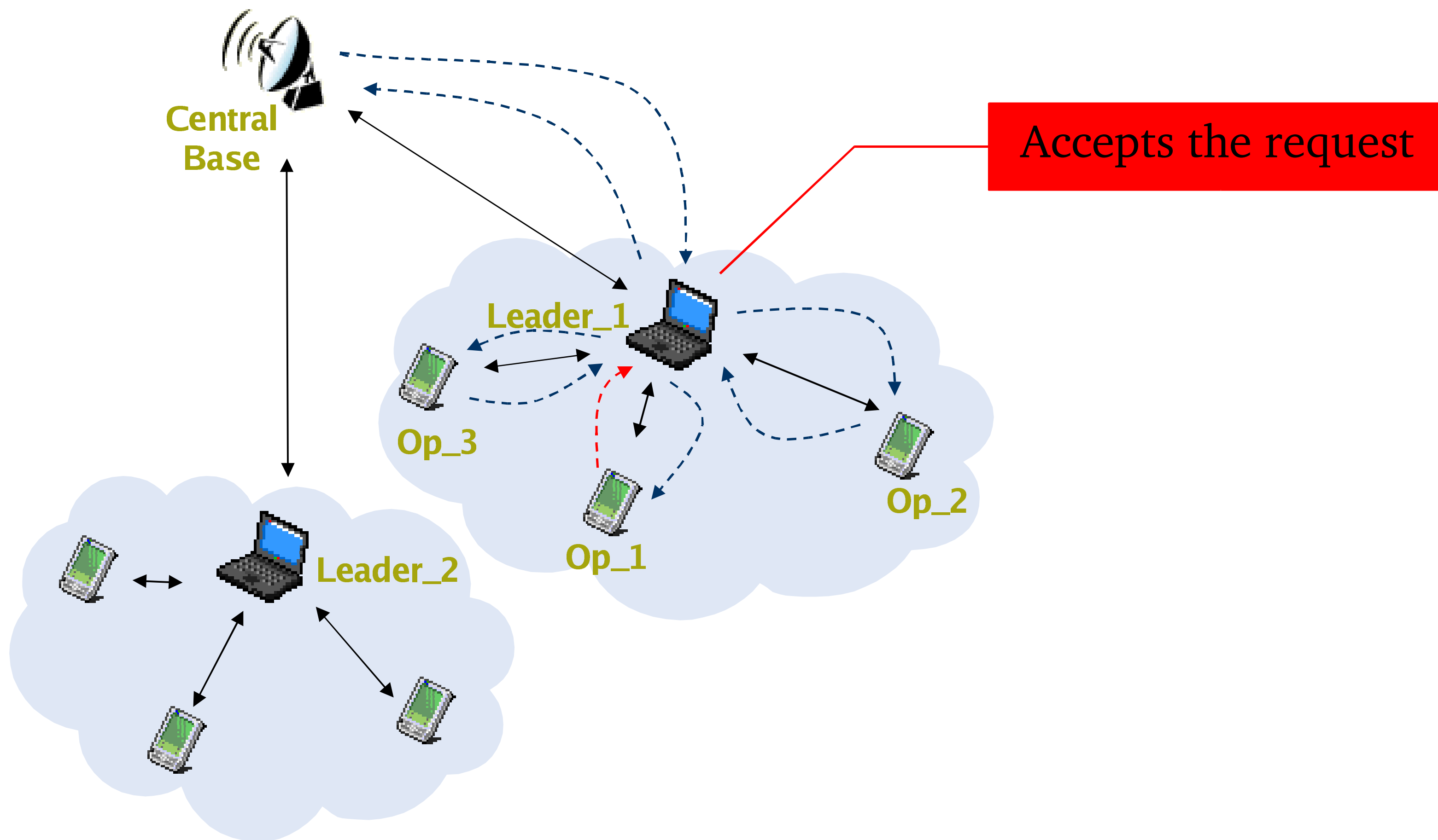

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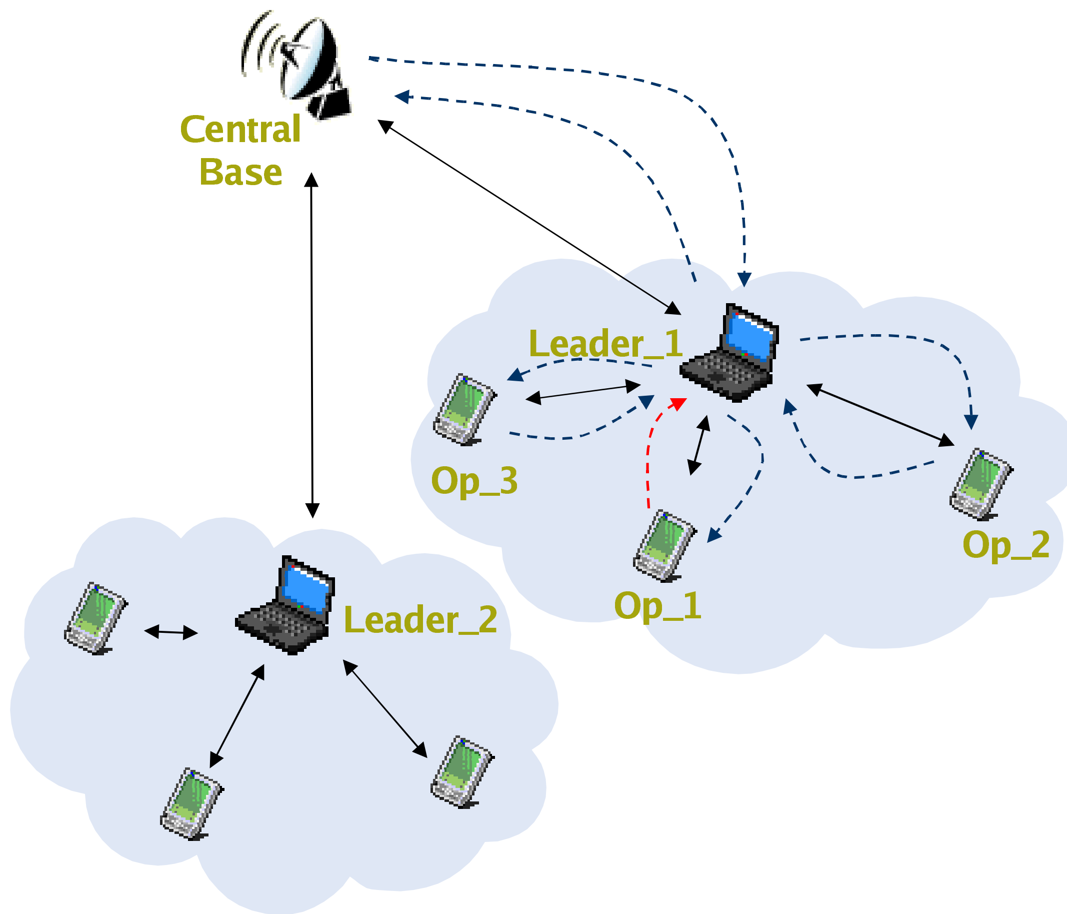

Exceptions:

- The Central realizes that A_1 is not longer needed
- The Leader_1 prefers to execute another activity
- Op_2 is unable to do A_1

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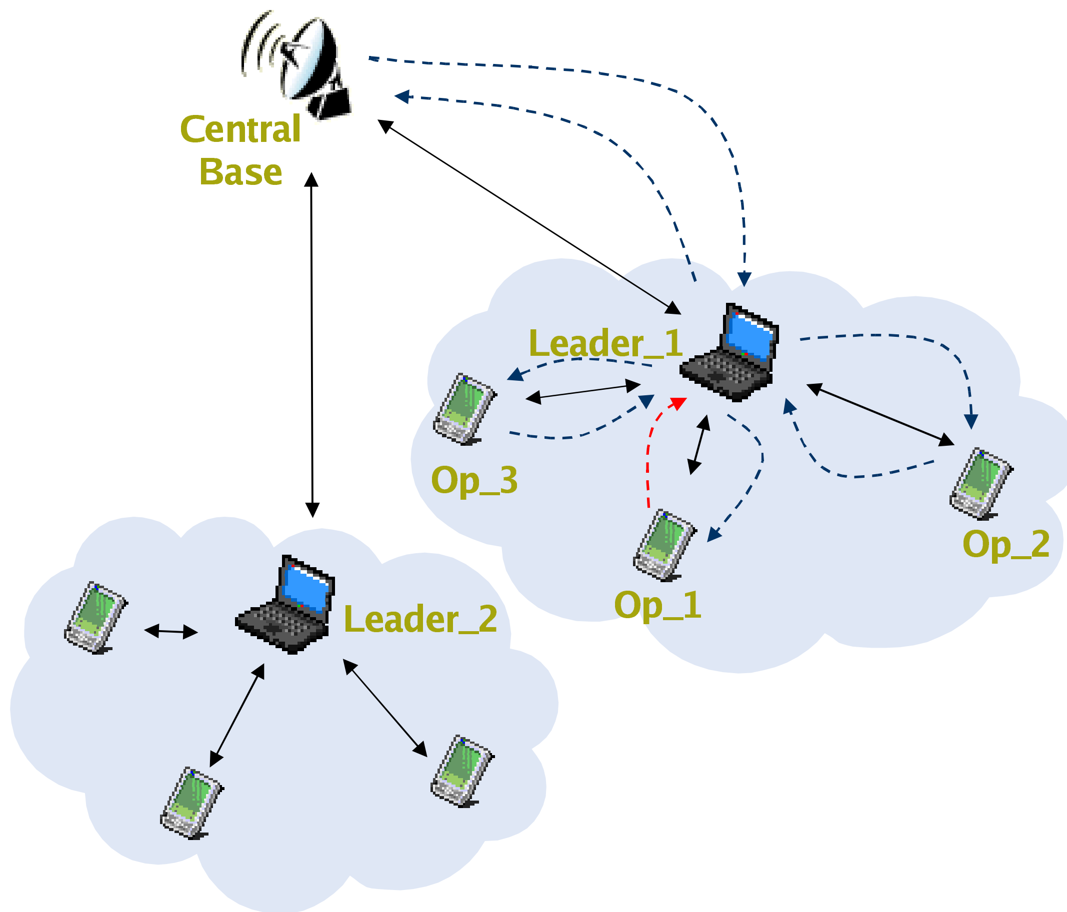

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We need an agreement mechanism!

Agreements

- The structure of agreements depends on the interactions among the different parties.
- Participants can dynamically join a negotiation.
  - Operators and leaders are getting involved in a negotiation during the execution of the agreement.
  - Neither the number nor the identity of parties are know statically.
- Asynchronous communication.

Coordination Pattern

- We rely on the *Distributed Two Phase Commit* (D2PC) of [BLM2002]:
  - A variant of the decentralized 2PC.
  - Finite but unknown number of participants.
  - A participant P ready to commit has a partial view of the set of participants
    - Only those who directly cooperated with P
  - P contacts all known partners and learns the identity of other participants from them.

D2PC: Initial state

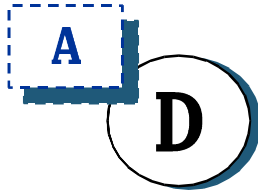
D

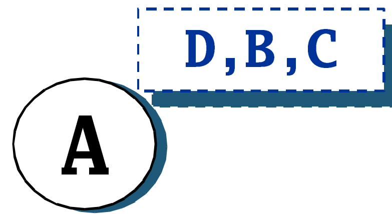
A

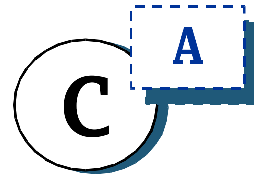
C

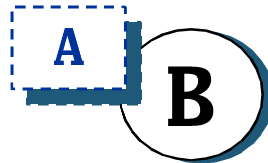
B

D2PC: Initial state









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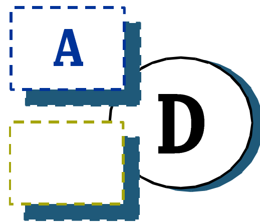
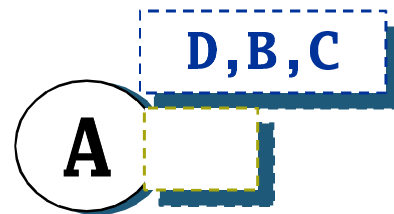
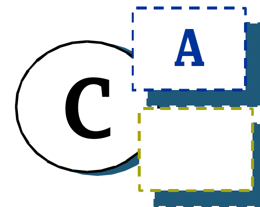
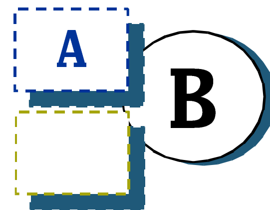
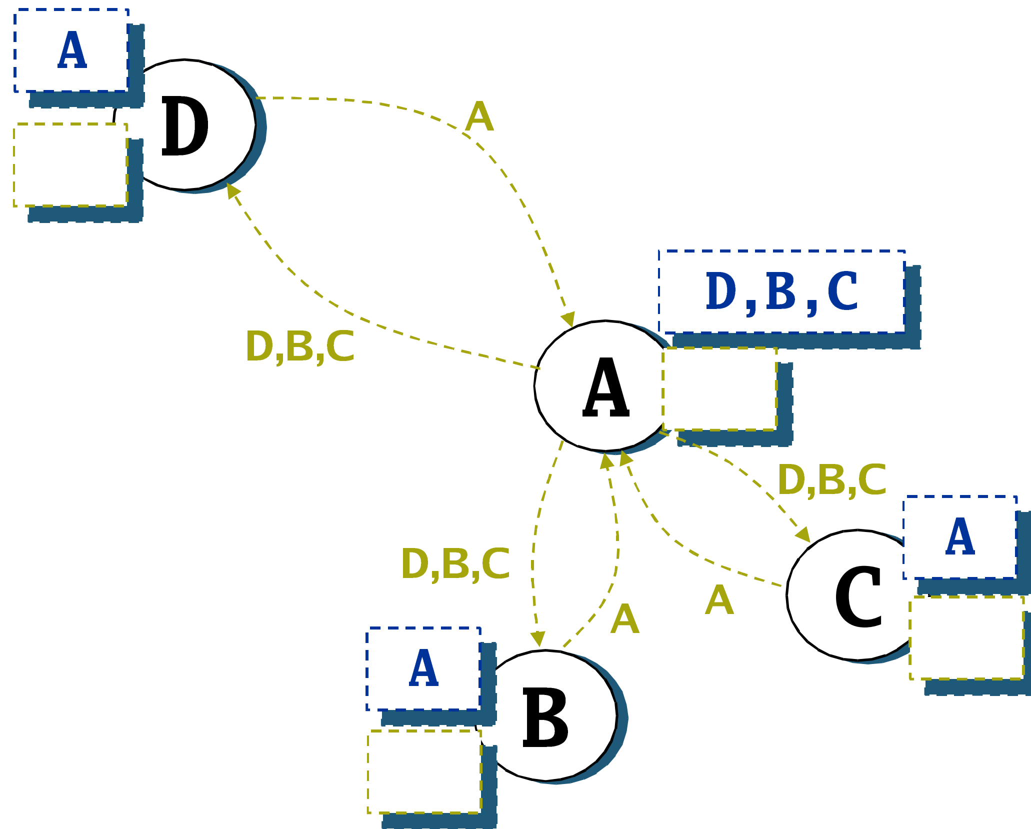








D2PC: Running



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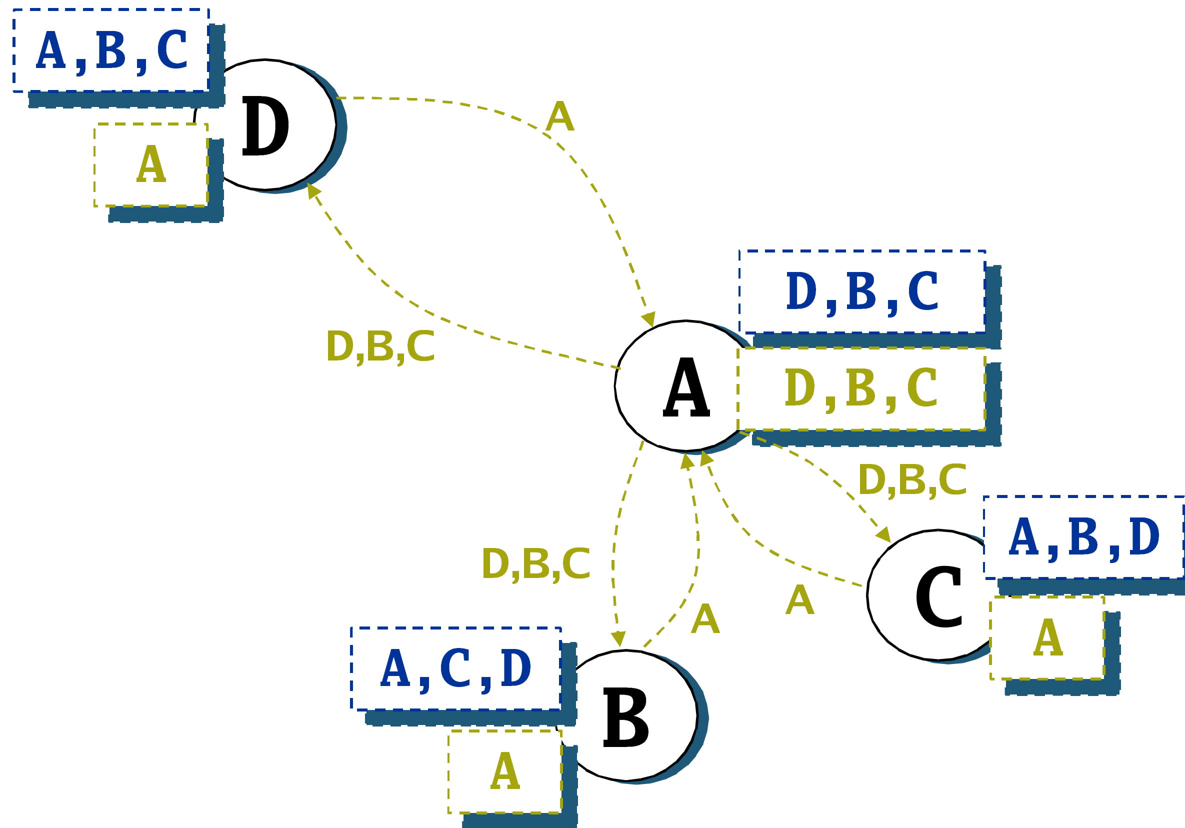

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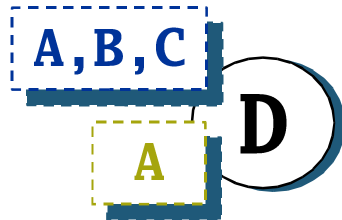

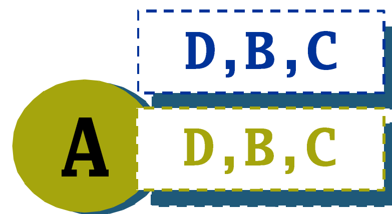

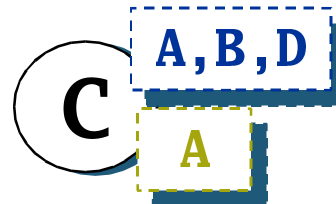

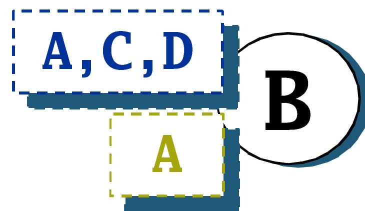

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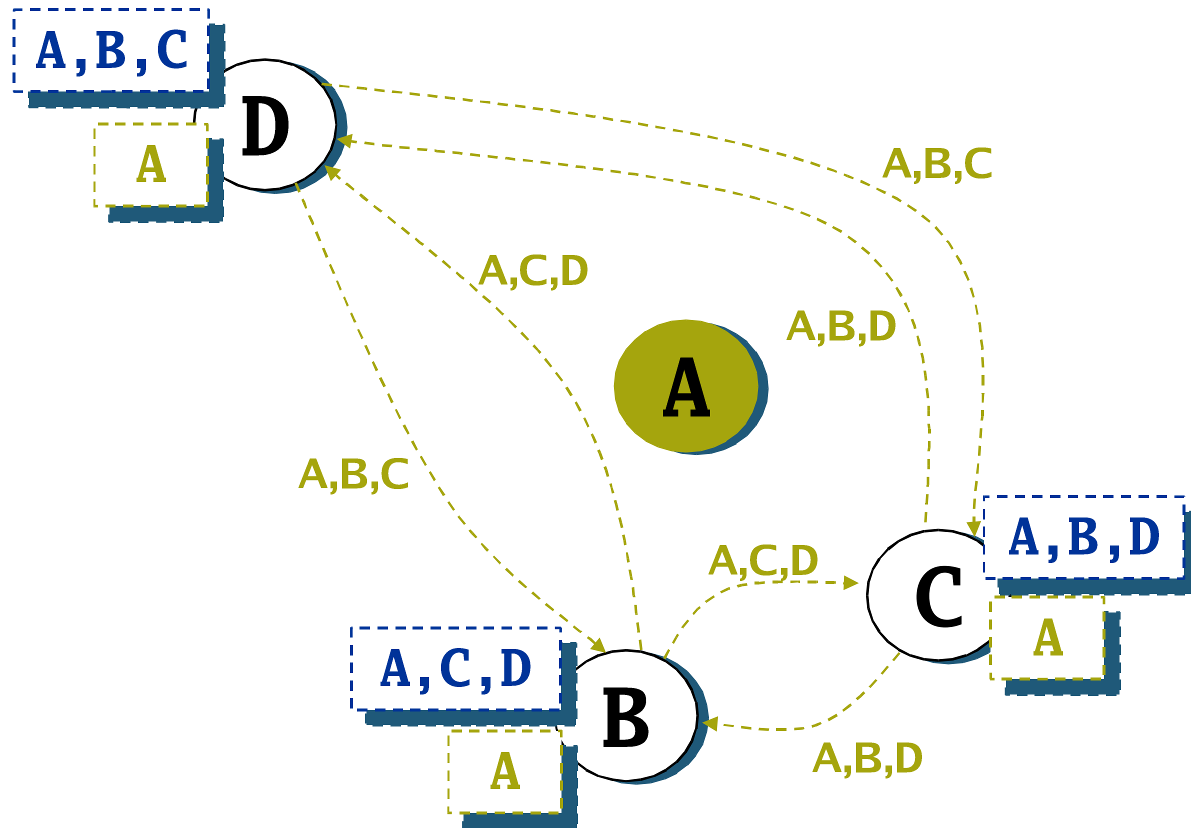

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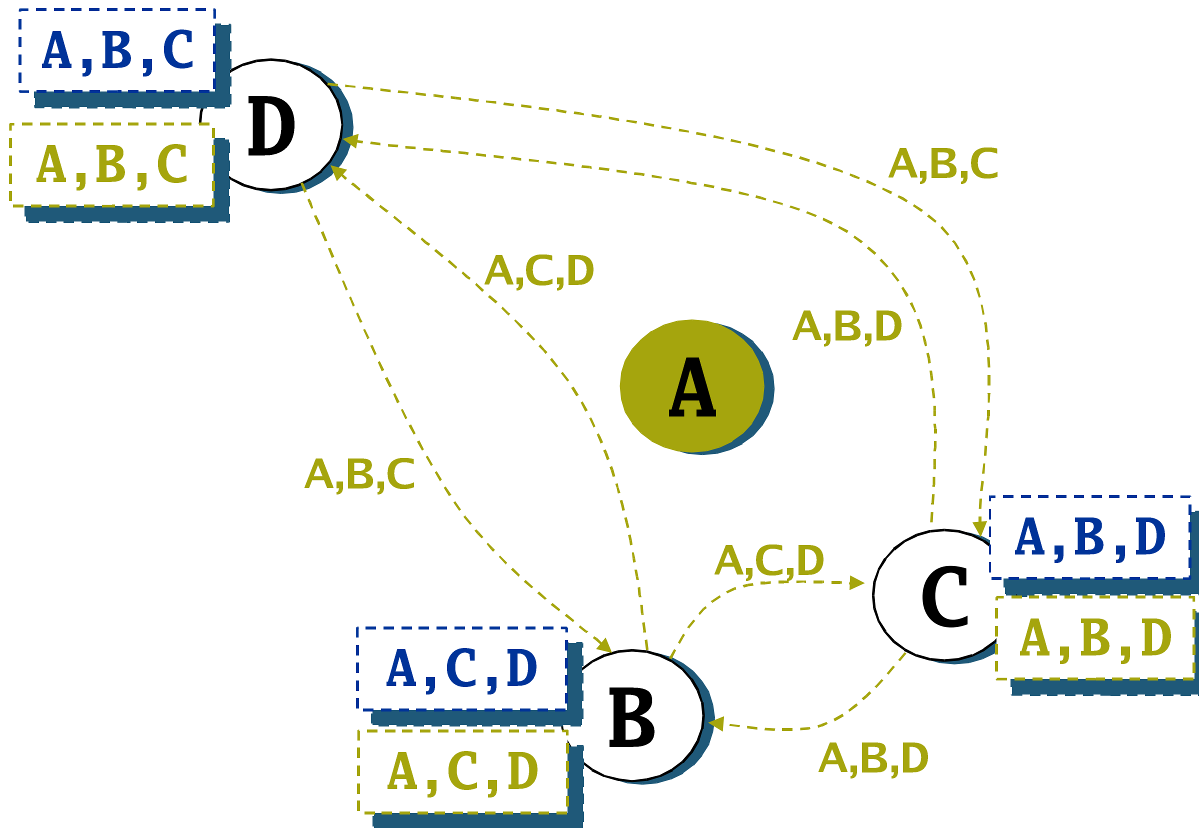

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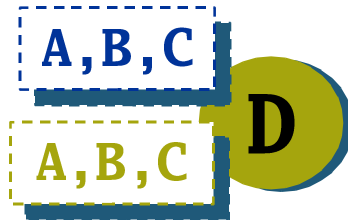
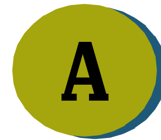
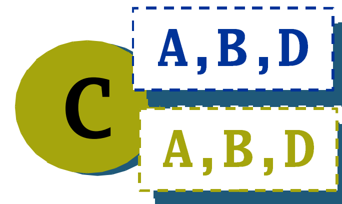


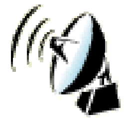




About the D2PC

- It has been specified in the Join Calculus.
- It was proposed to encode zero-safe nets in Join.
- It has been proved to be *correct* when there are no failures.

Coordination Pattern



Central
Base

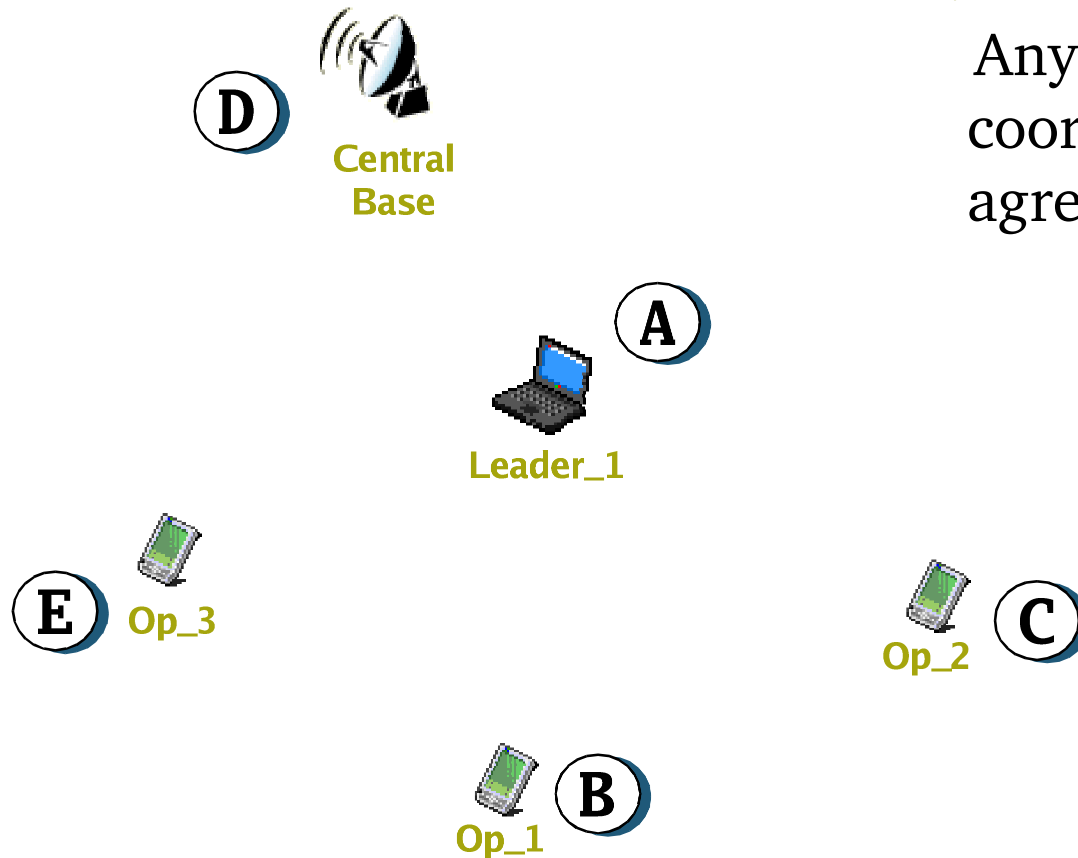
Leader_1

Op_3

Op_2

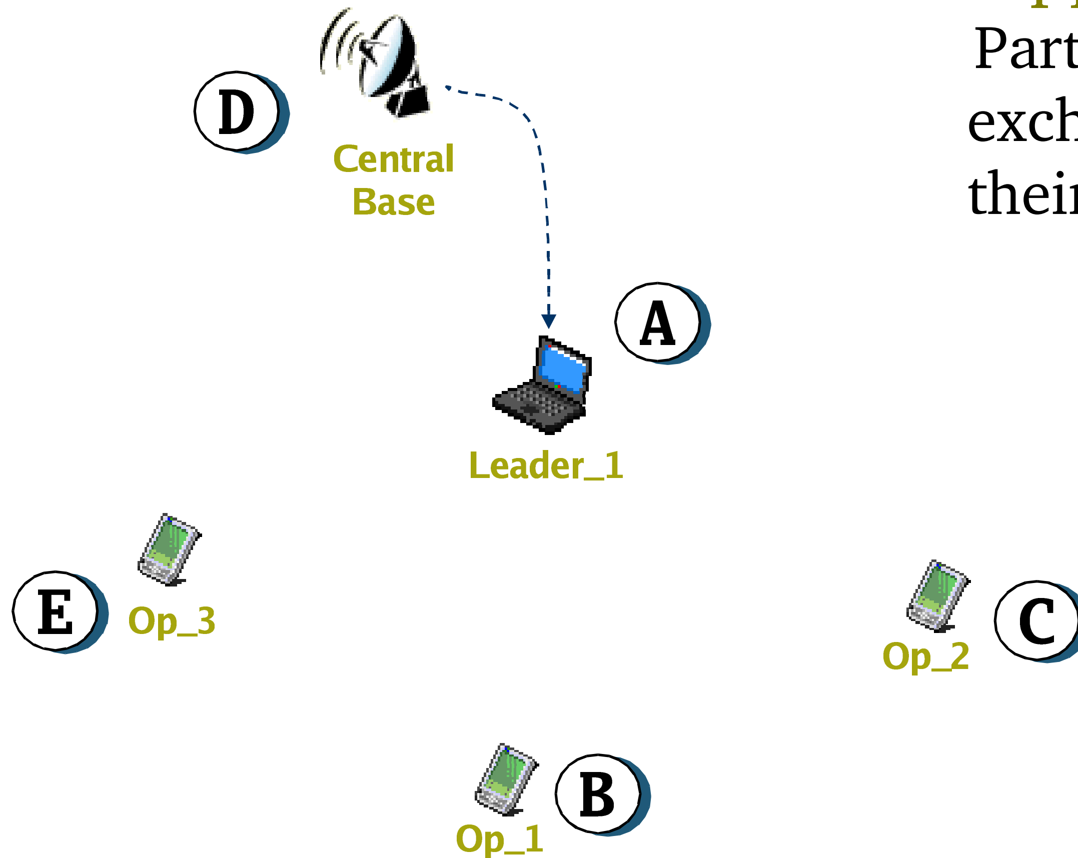
Op_1

Coordination Pattern



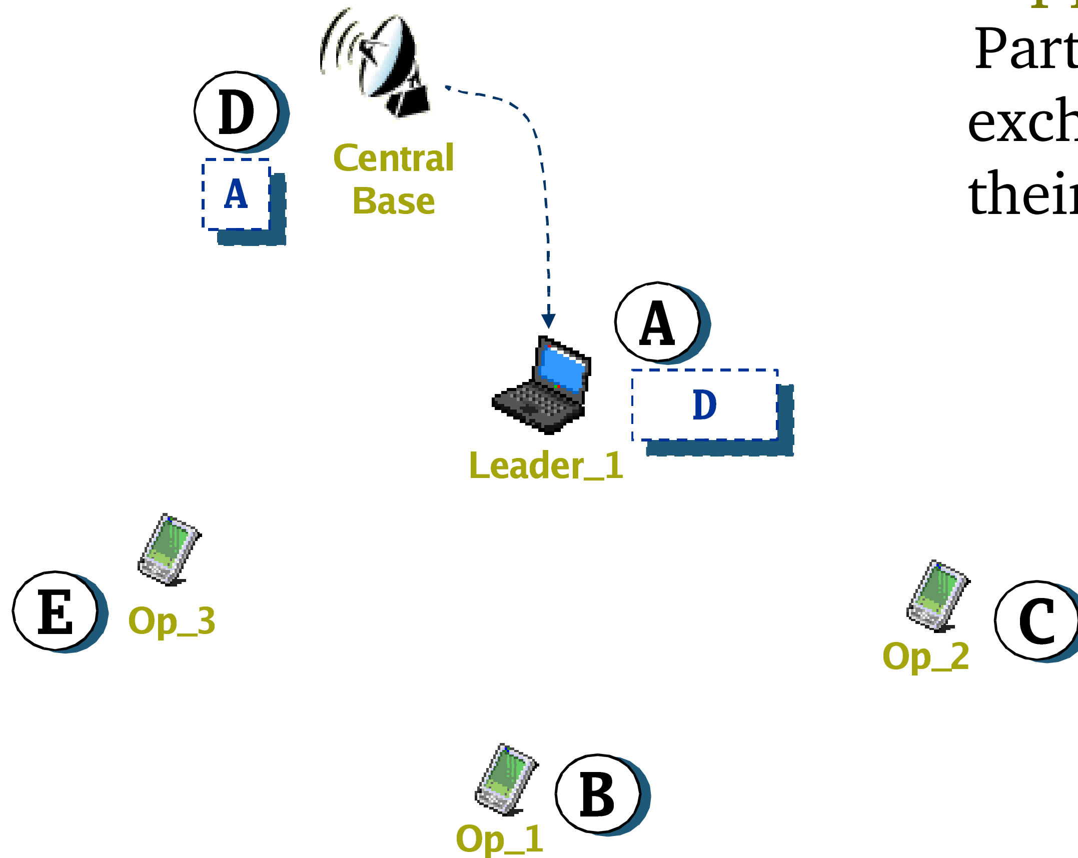
1. Initialization:
   Any participant creates a coordinator to handle the agreement

Coordination Pattern



2. Application Logic:
Participants interact and exchange the identities of their coordinators

Coordination Pattern



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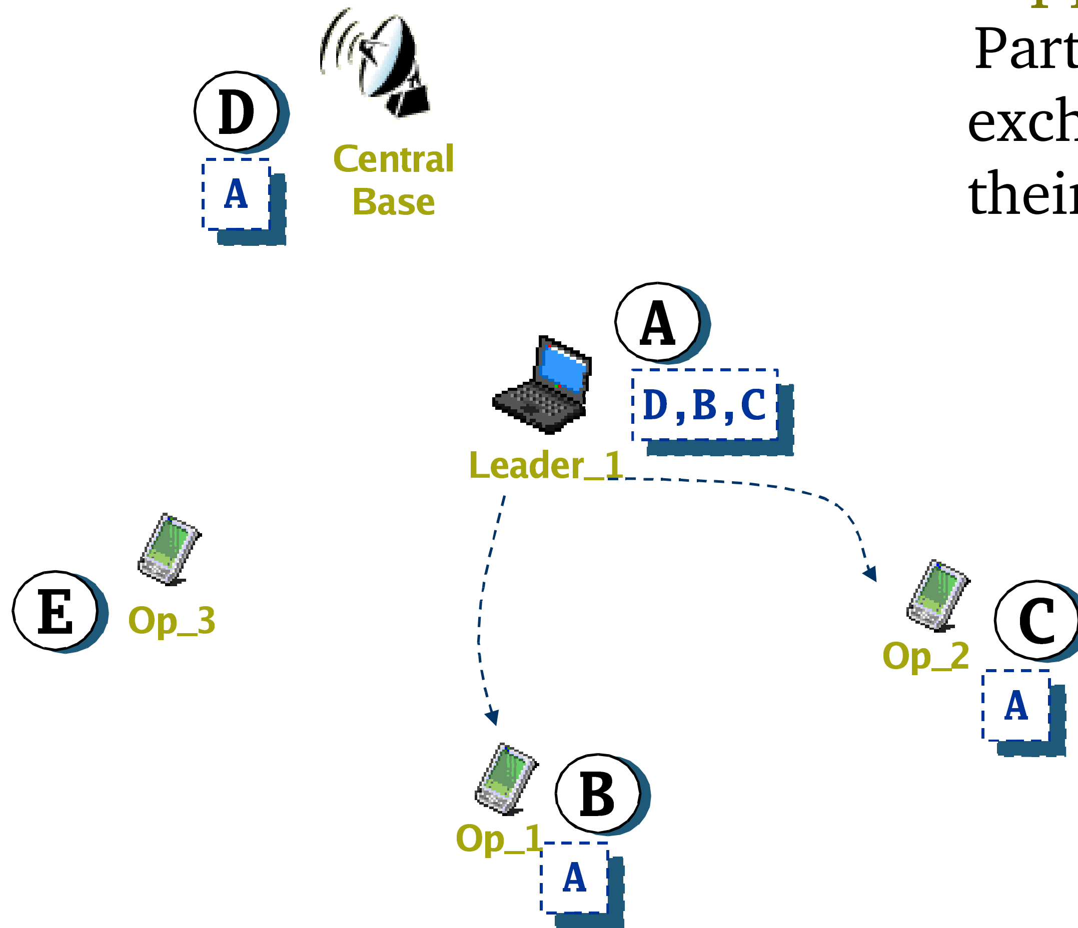

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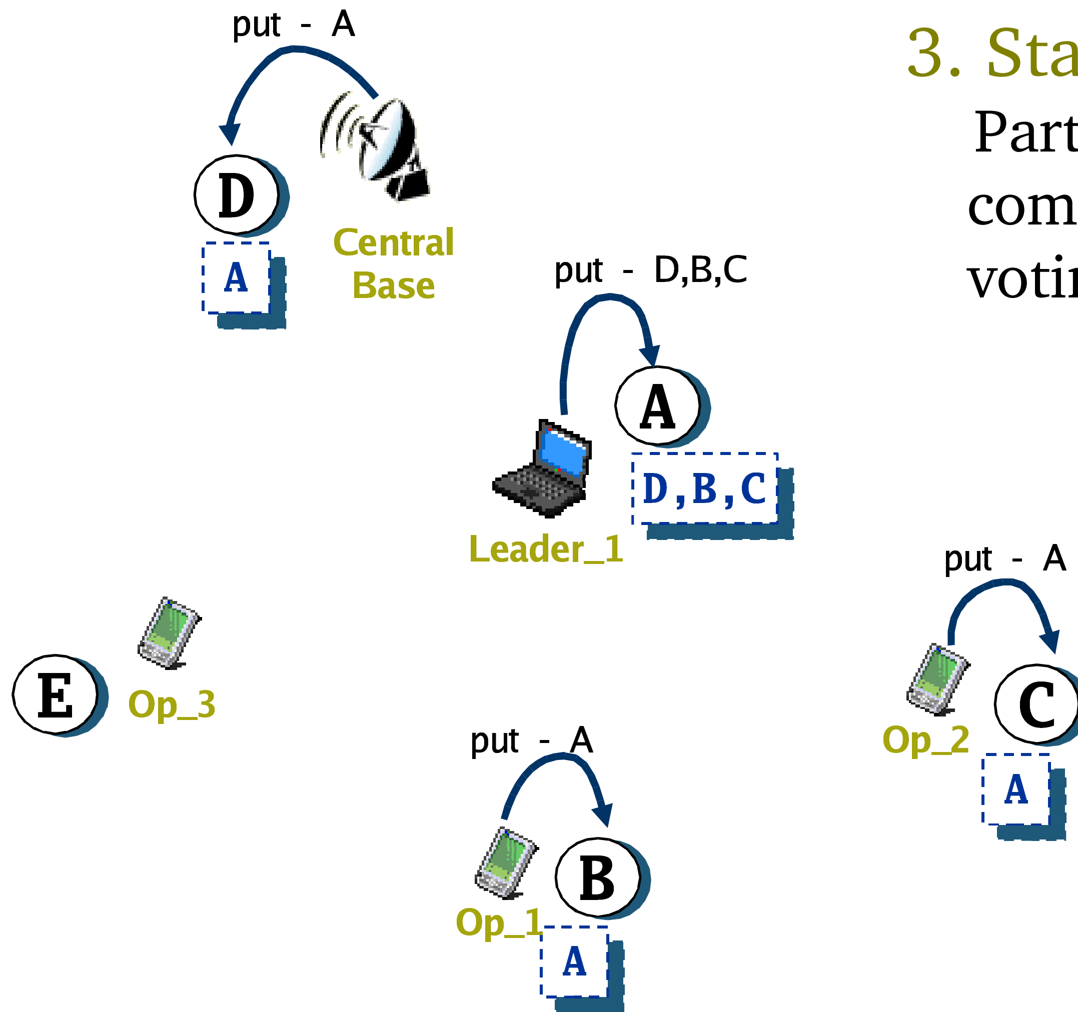
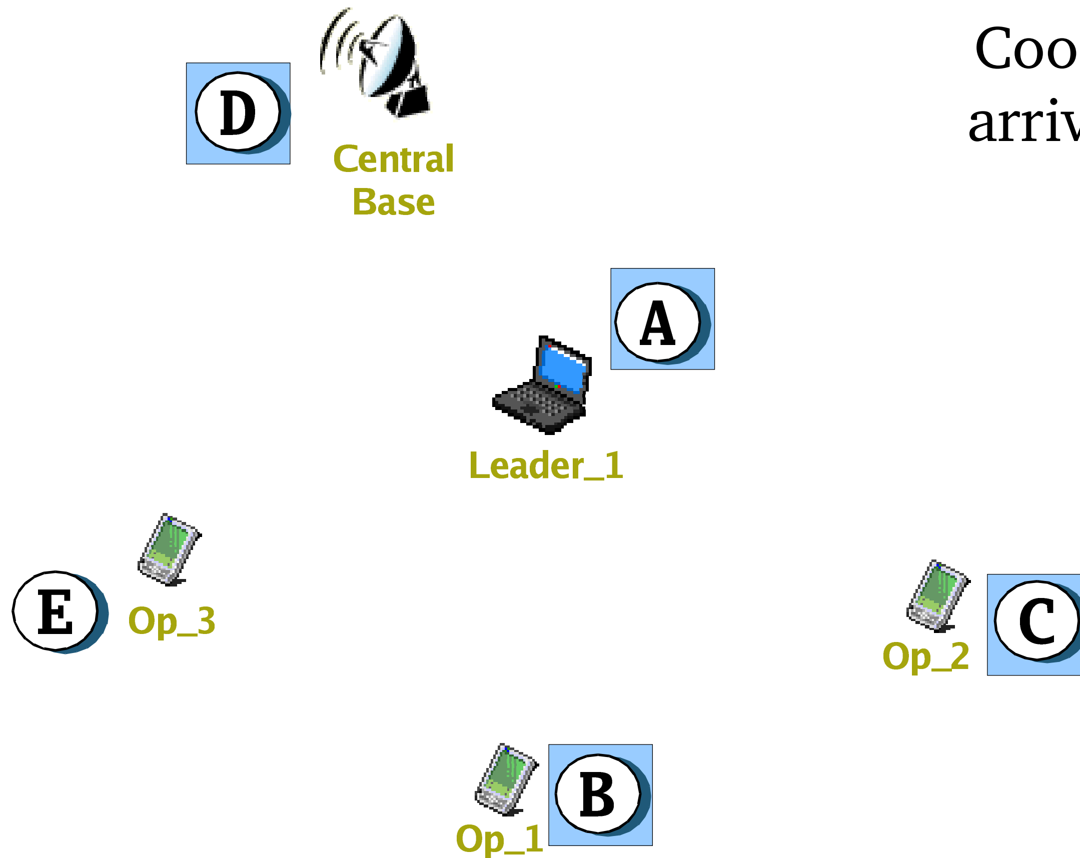


3. Start of the D2PC:

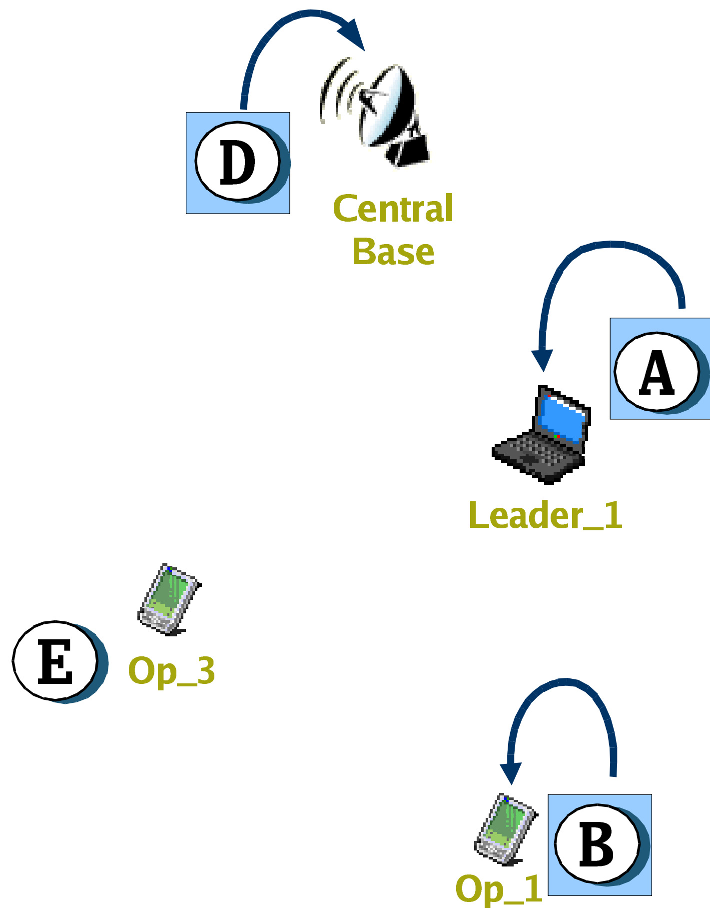
Participants start the commit protocol either voting commit or abort

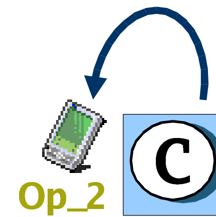
Coordination Pattern



4. Execution of D2PC:
Coordinators eventually arrive to an agreement

Coordination Pattern





5. Communication of the result:

Coordinators notifies the application with the result of the agreement

Implementation (1)

- A prototype implementation for a minimal set of functionalities:
  - Users exchange textual messages.
  - Users can decide either to commit or to abort.
  - Users see the outcome decision.
- Parties have been developed in:
  - Jocaml + Perl running on Linux.
  - Polyphonic C# (or Comega) running on .Net.
  - They can interact, i.e., participate in a negotiation.

Implementation (2)

- Any party is identified with a unique ID (provided when the application is launched).
- A configuration file associates IDs to IP addresses.
- The ports in which parties communicate depend exclusively on the ID.

Implementation (3)

- Parties communicate through TCP sockets

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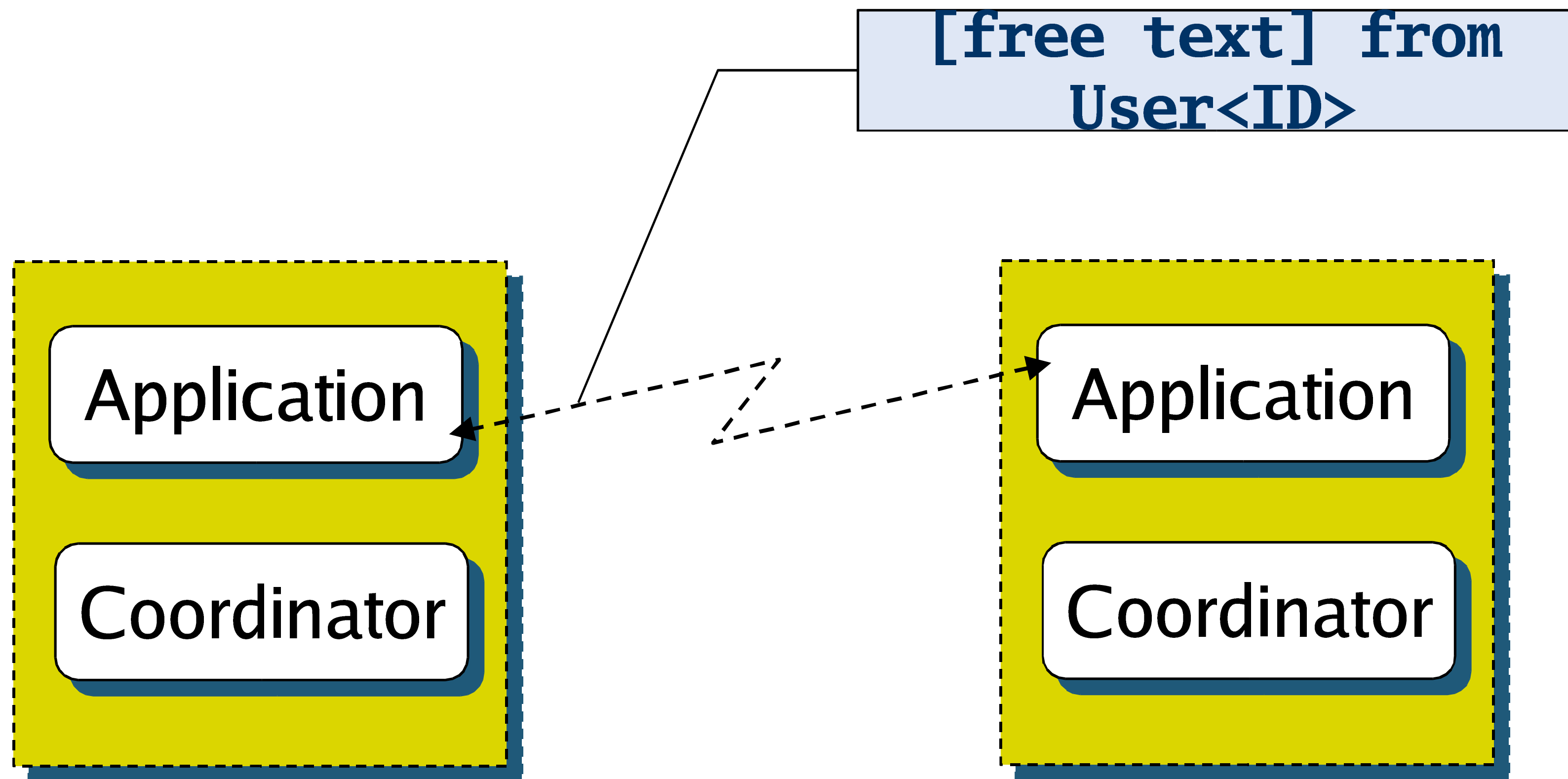

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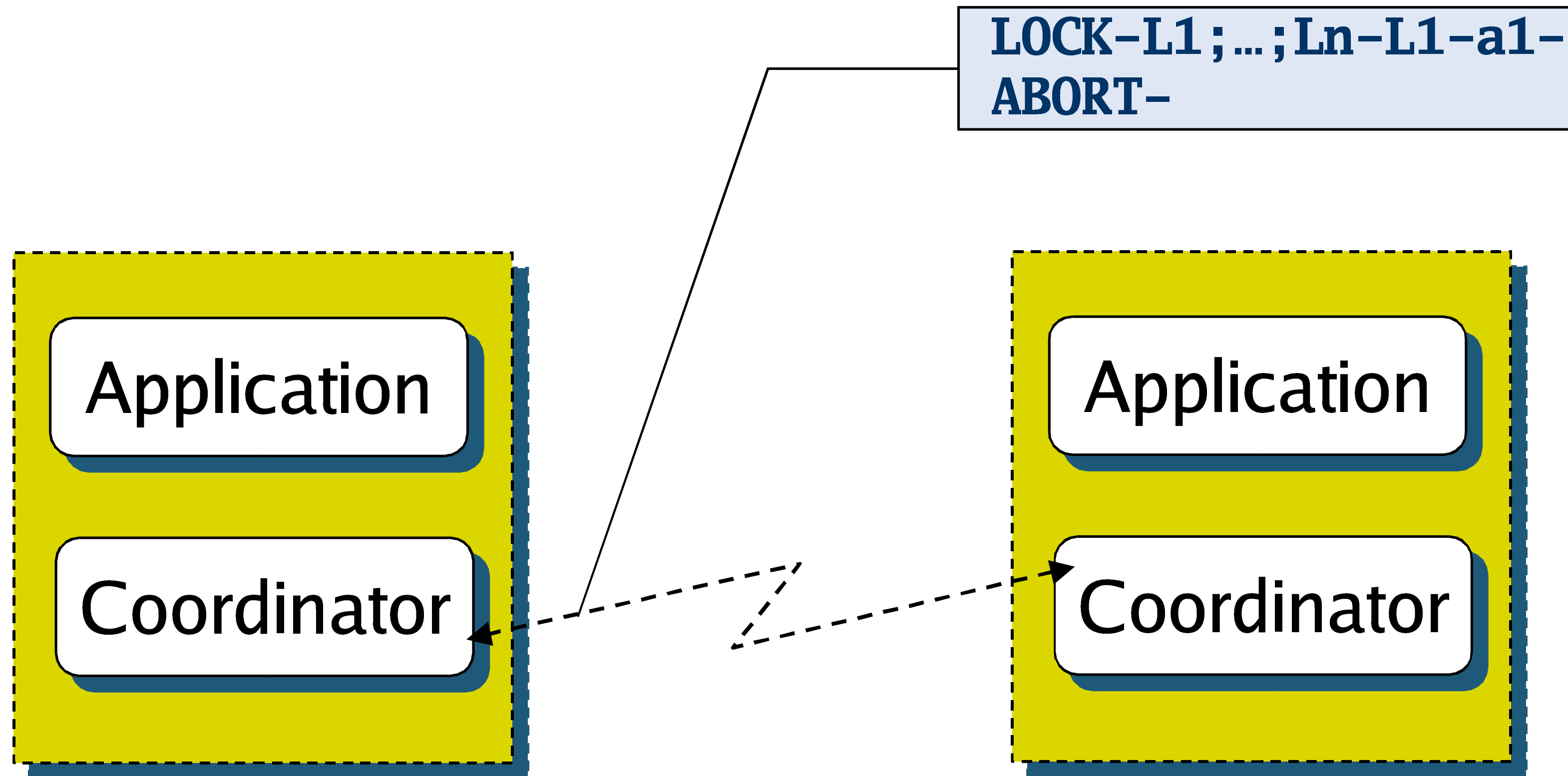
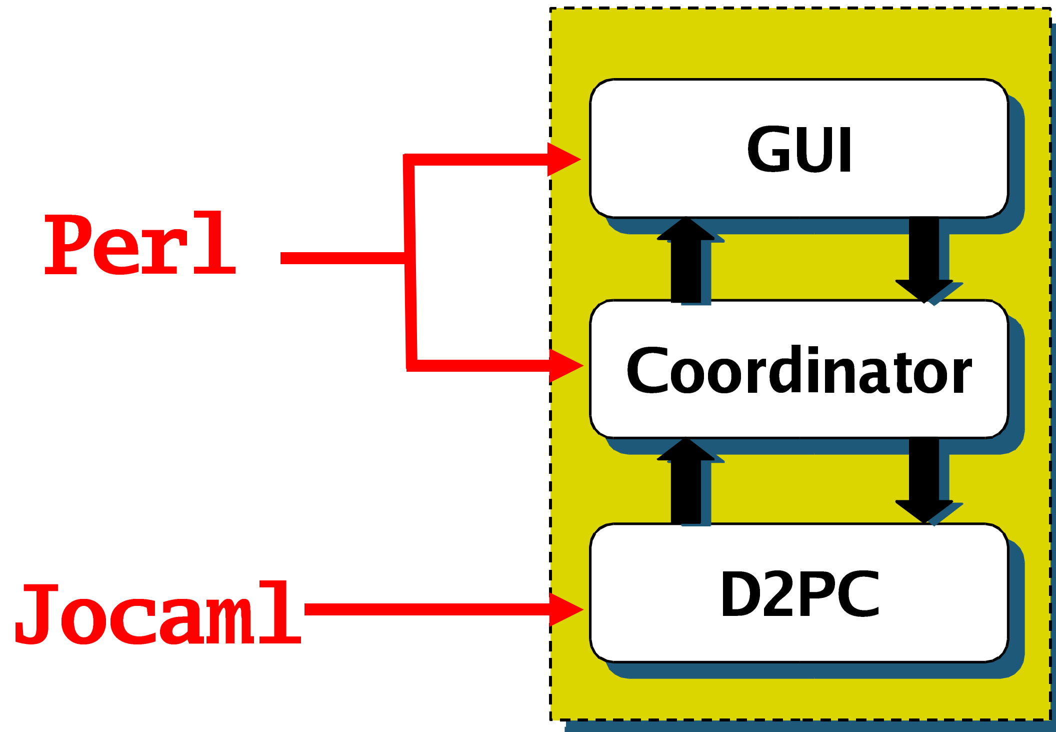


Perl+Jocaml Components

- Three-Layer Architecture



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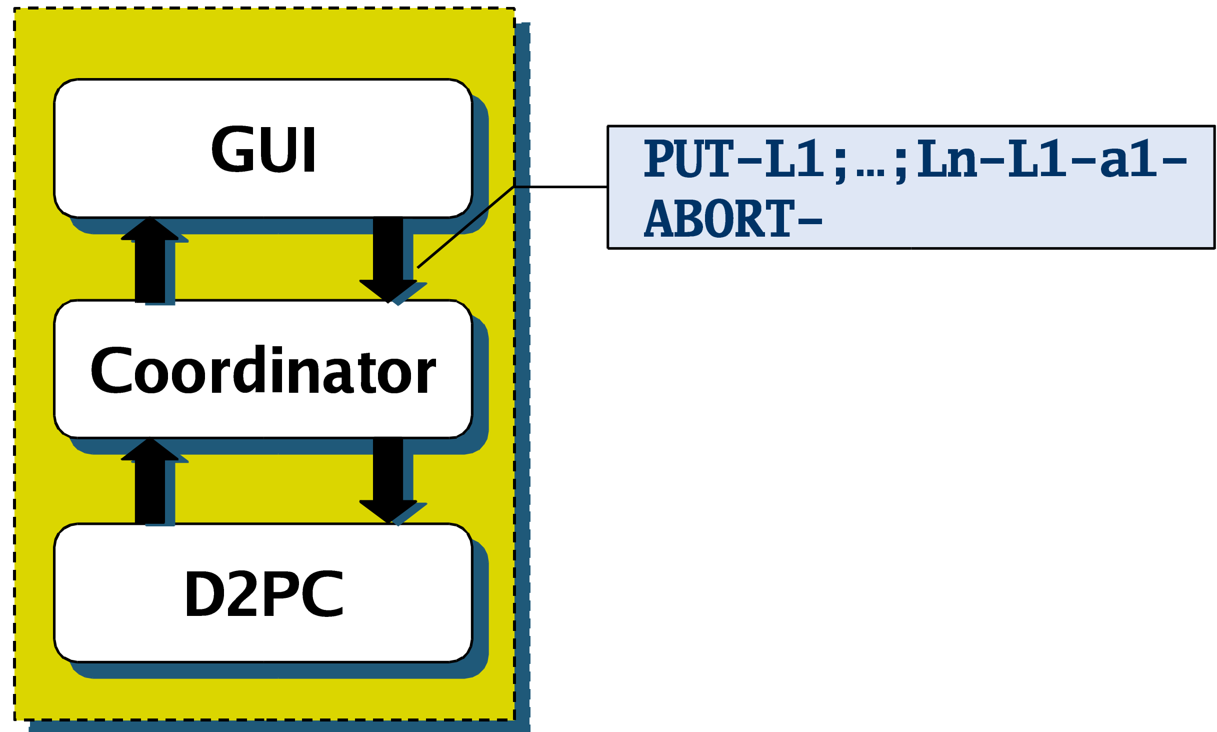

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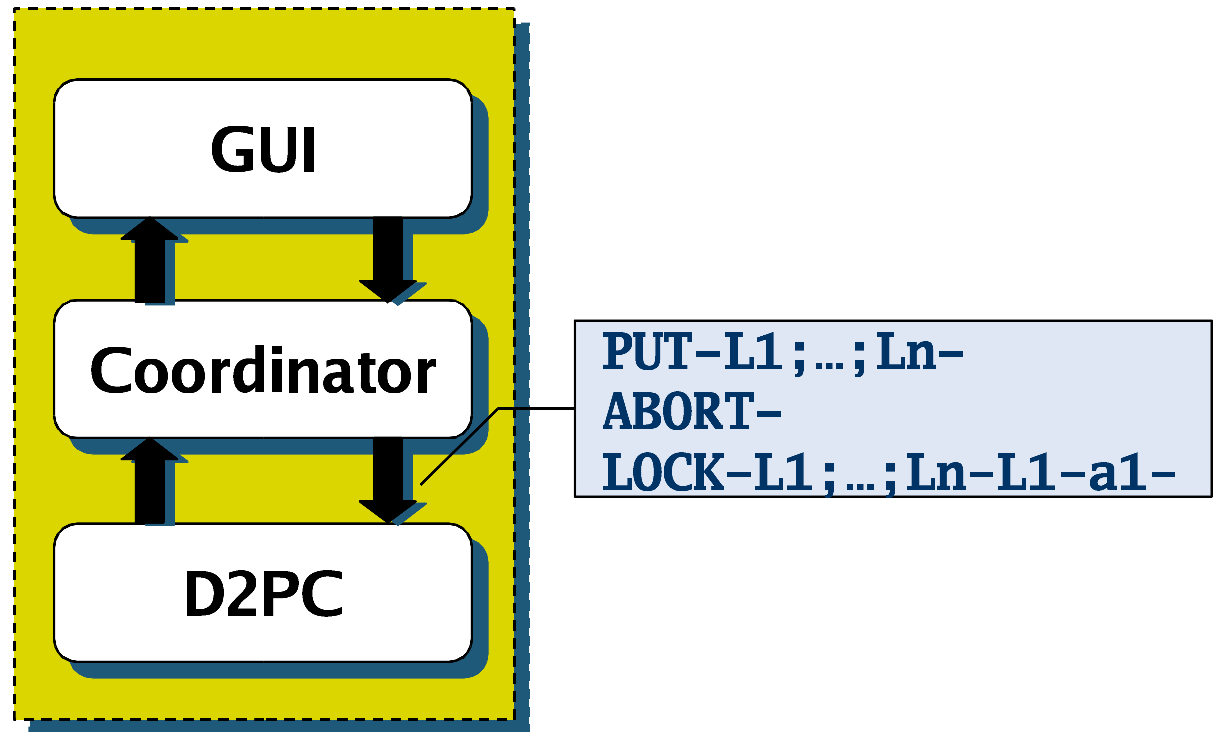

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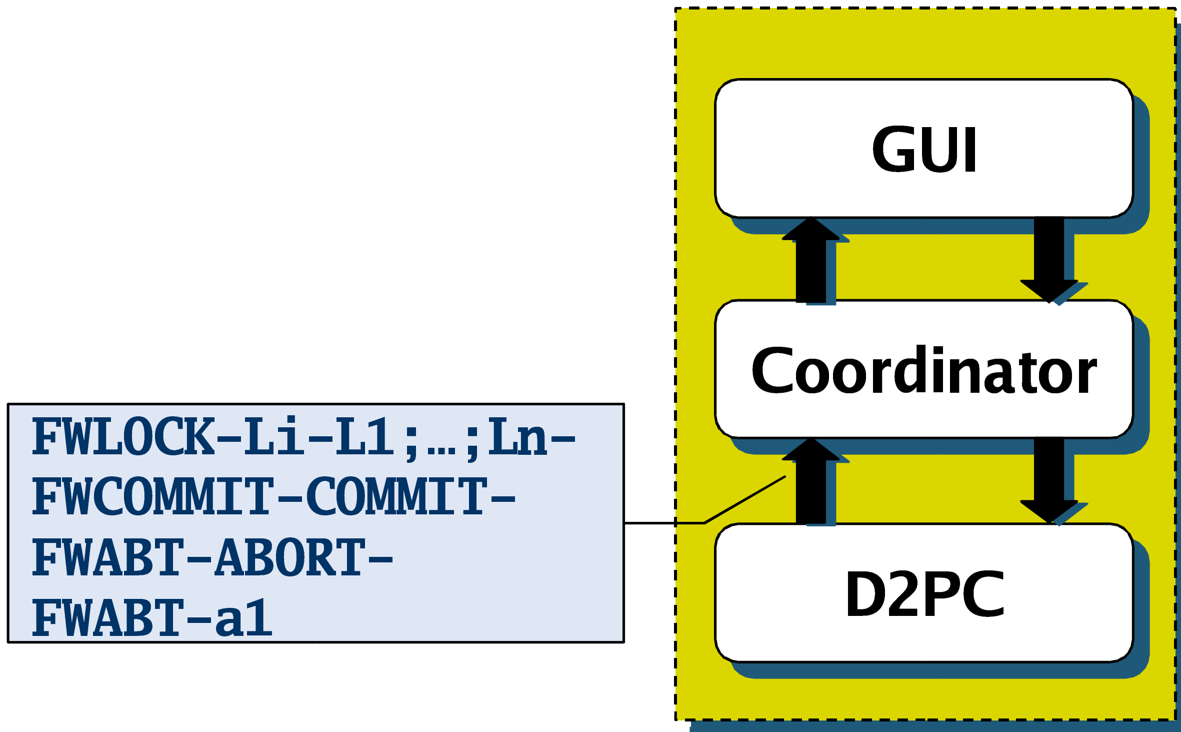

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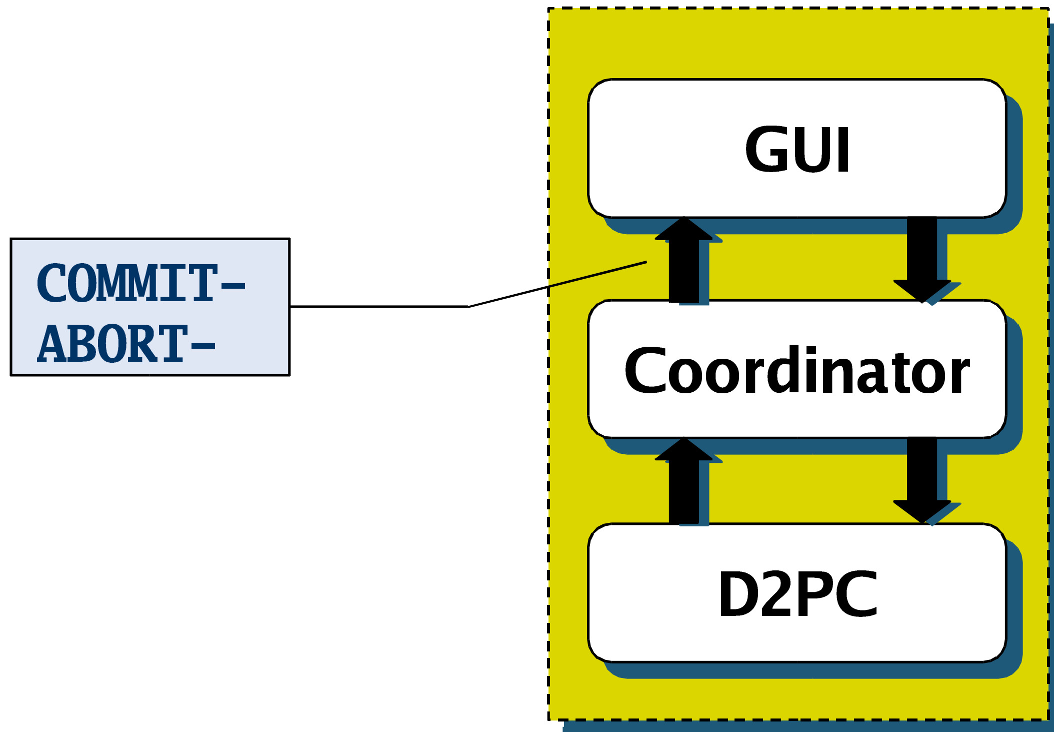


Jocaml Coordinators

- Jocaml is an extension of Ocaml with:
  - Processes: Expressions + Async Messages.
  - Channels, i.e., join ports
  - Join patterns

```
let def a! h | b! () =
      if h < 5 then c() else d();;
```

Jocaml Coordinators

```
let def d2pc () =
  let def
        state! h | abt! () =  failed() | fwdabt [h]
    or failed!() | abt! () = failed ()
    or failed!() | lock! (l1,l,a) = failed () | fwdabt [a]
    or failed!() | put!(l,a,c) =  failed () | fwdabt a
    or commit!(l,l1,l2,c,a) | abt!() = failed() | fwdabt a
    or commit0!(l,l1,l2,c,a) =
         match l with
                [] -> if (equiv l1  l2) then fwdcmt [c]
                      else commit(l,l1,l2,c,a)
              t::ts -> fwdlock(t,l1) | commit0(ts,l1,l2,c,a)
    or commit!(l,l1,l2,c,a) | lock!(l3,l1,f) =
         commit0 (difference l3 l1, union l1 l3,
                     union l2 [l1],c,union a [f])
    or state! h | put! (l,a,c) =
         commit0 (del lock l, l, [lock], c,union a h)
in reply lock,put,commit,state;;
```

Polyphonic C# Components

- Polyphonic C# extends C# with:
  - Asynchronous methods: any call is guaranteed to complete almost immediately.
  - Chords defined by:
    - *A header*: a set of method declarations separated by **&**.
    - *A body*, which is executed only once all the methods in the header have been called.

Polyphonic C# Components (2)

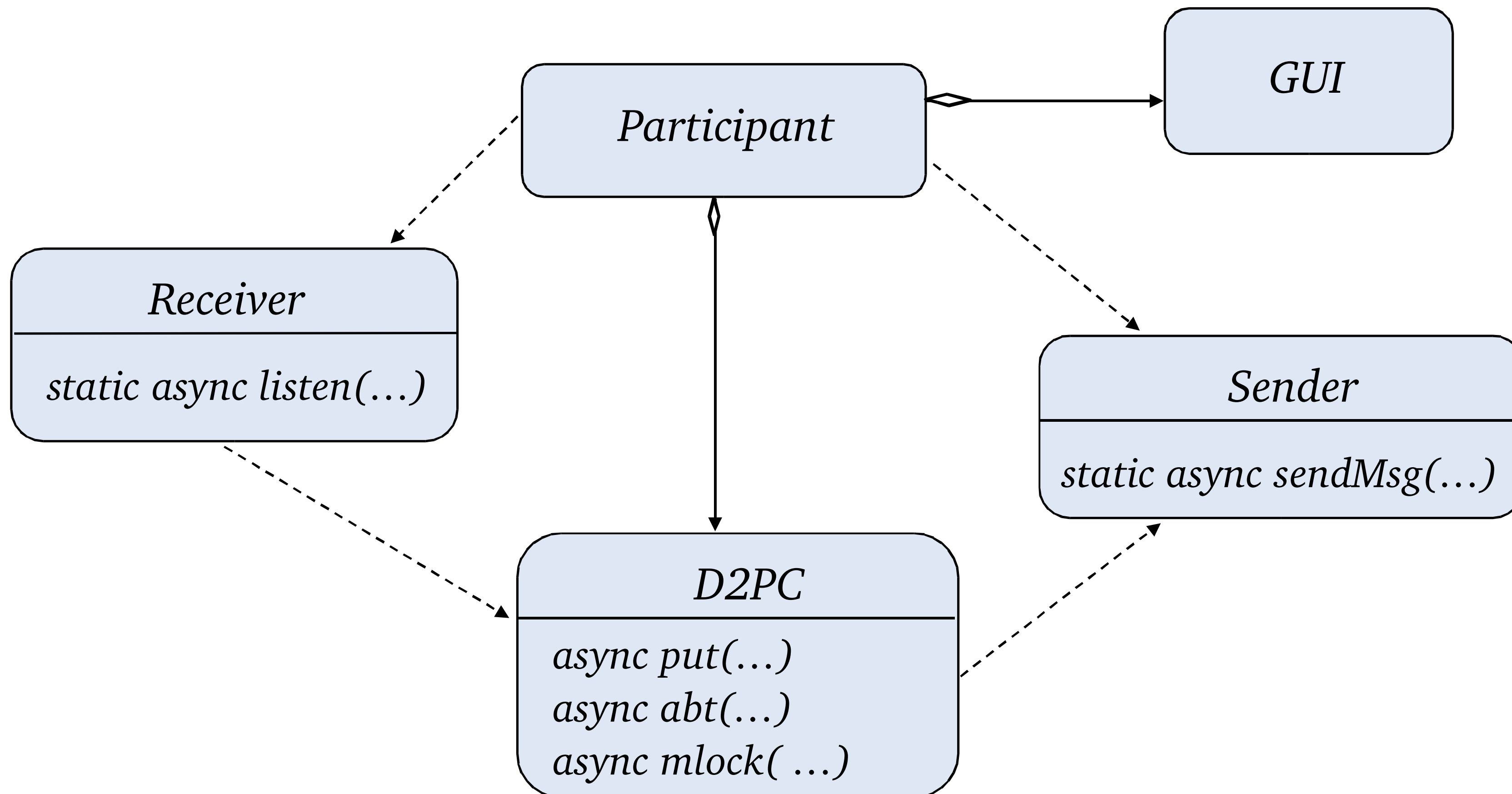
- Polyphonic C# class for the D2PC

```
public class D2PC{
  public async put (listhost l, port a, port c);
  public async abt();
  public async mlock(listhost ll, port l, port a);

  private async state(port h);
  private async failed();
  ....
  when state(port h) & abt(){failed ();...}
  when failed() & abt(){failed();}
  when failed() & mlock(listhost ll, port a, portl){
      failed();}
  ...
}
```

Polyphonic C# Components (3)

- Class Diagram (partial view).



Demo …

Future work

- Extending the D2PC for handling failures.
- Combining the D2PC with the standard 2PC protocol.
- Adding a mechanism for the dynamic discovery of participants (instead of using a configuration file).
- Implementing all the functionalities of the rescue team scenario.