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# **Speculations on Coordination Models**

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## Acknowledgements

This talk was inspired by some work of Marcelo Cataldo and Jim Herbsleb. They are interested in *actual* coordination mechanisms. This talk is about characterizing *possible* coordination mechanisms.

I would also like to thank Marcelo and Jim for their comments on an earlier draft.



## **What is the situation under consideration?**

I am concerned with the coordination situation after development has begun.

This means that people are involved in the coordination if the existing documents are not adequate.

It could be that the coordination is done by modifying or producing new documents but, in this case, people must develop the documents.

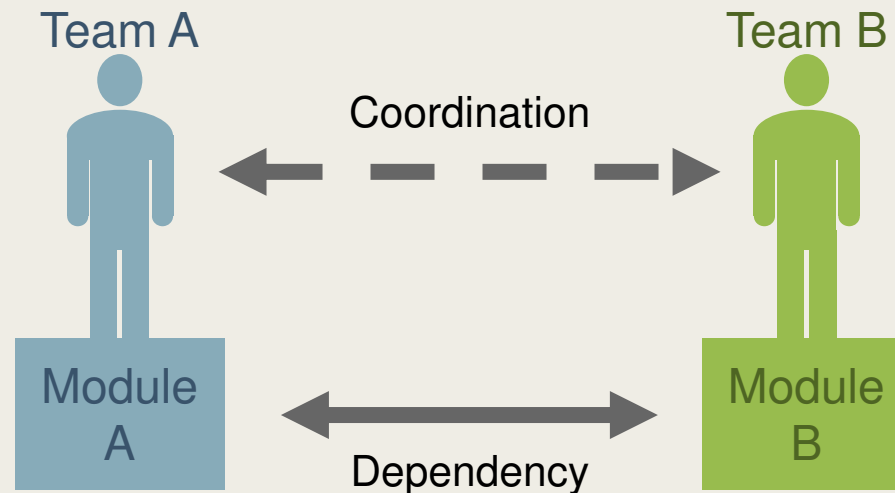
My focus is on structure, not on behavior. Behavior is important but the two must both be treated to get an adequate picture of the coordination.



## Premise

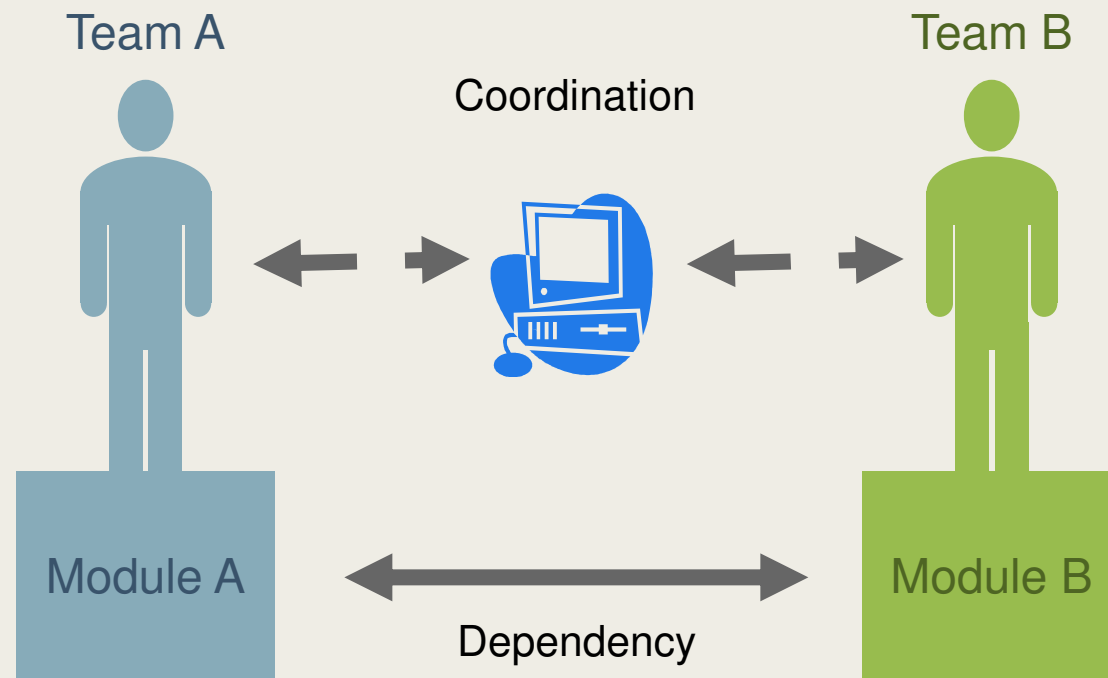
Modules (units of development) in software are created by teams

Teams need to coordinate if one module has a dependency on another.





## Coordination may be mediated by technology



The notation I am developing will not show technology but it is implicit



## **Teams are composed of individuals**

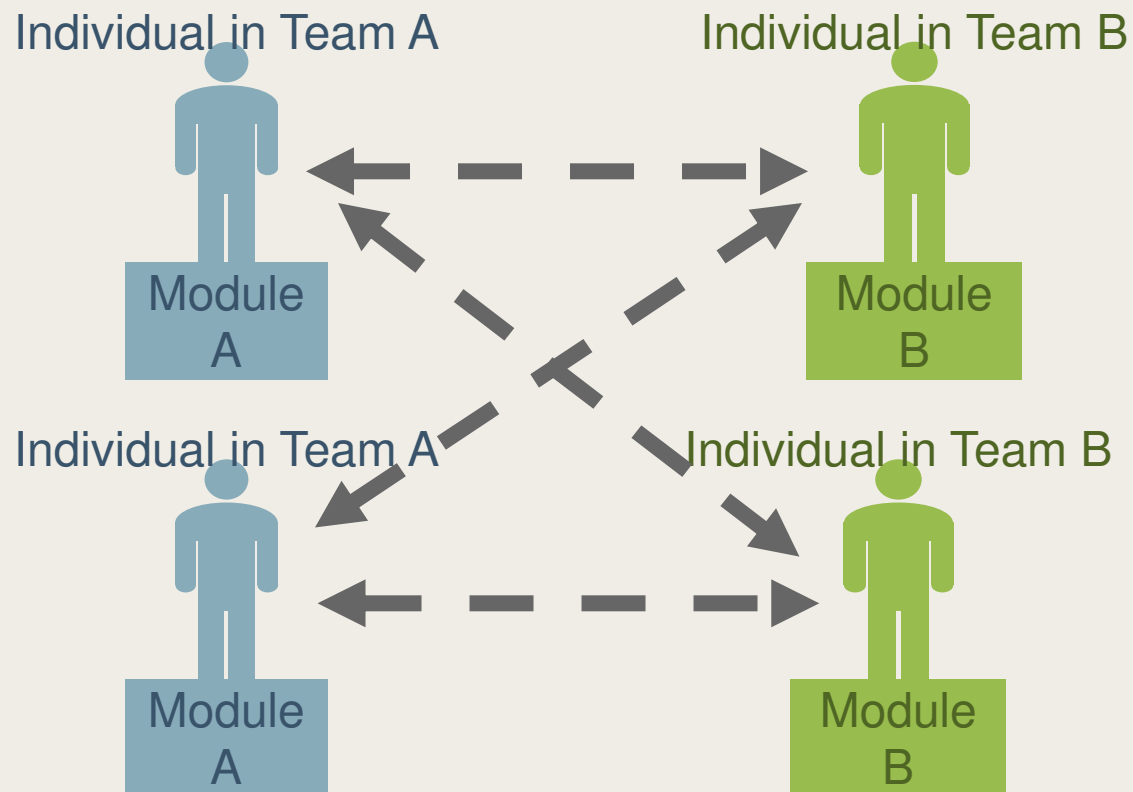
What does it mean for Team A to coordinate with Team B?

It means the individuals within Team A must coordinate with the individuals from Team B.

This is the level of decomposition I am going to explore in this talk.



# Individual Coordination Requirements





## A x B coordination

If there are  $M$  team members in Team A and  $N$  team members in Team B, then allowing any team member from one team to coordinate with a team member from another team leads to  $M \times N$  coordination paths.

### Positives

- No loss of information in coordination
- No loss of time in coordination

### Negatives

- Individuals may spend much of their time coordinating.
- Unavailability of individuals may lead to delays
- Responsibilities of team members must be known externally. Could cause problems if responsibilities change or if module B changes.

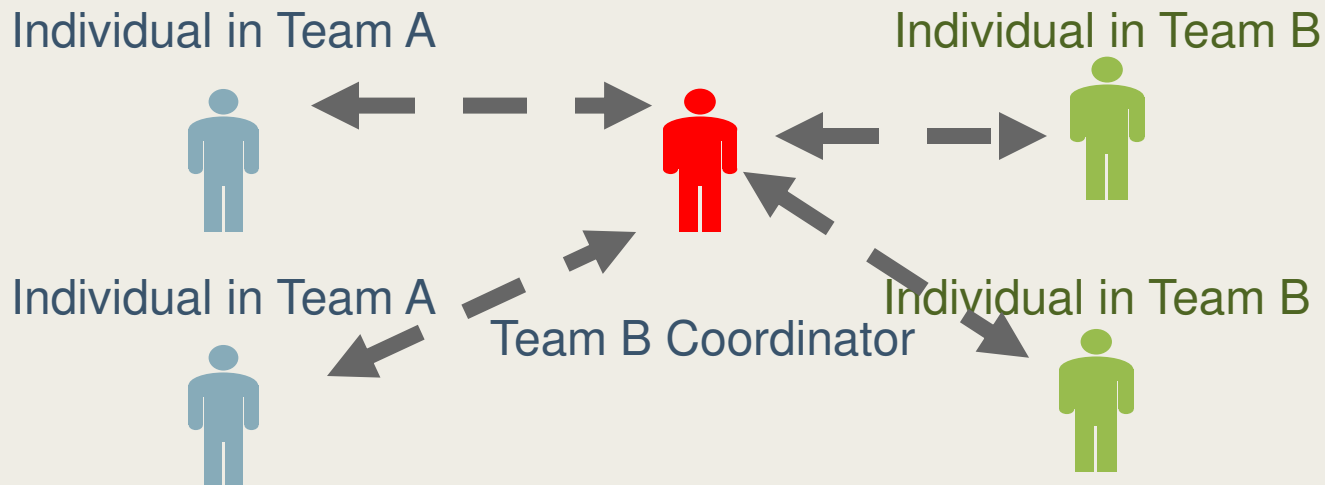




## A x 1 ← - B

Team B has a single individual whose responsibility it is to coordinate with Team A.

Any individual in Team A can coordinate with the coordinator for Team B but not with any other members of Team B.





## A x 1 ← B (continued)

Positives:

- Changes in responsibilities of members of Team B are hidden
- All members of Team A know with whom to coordinate in Team B
- Coordinator for Team B gains overall understanding of module. Good career path.
- Interruptions of other team members of Team B reduced.
- Coordinator gains confidence of Team A.



## **A x 1 <- B (continued – 2)**

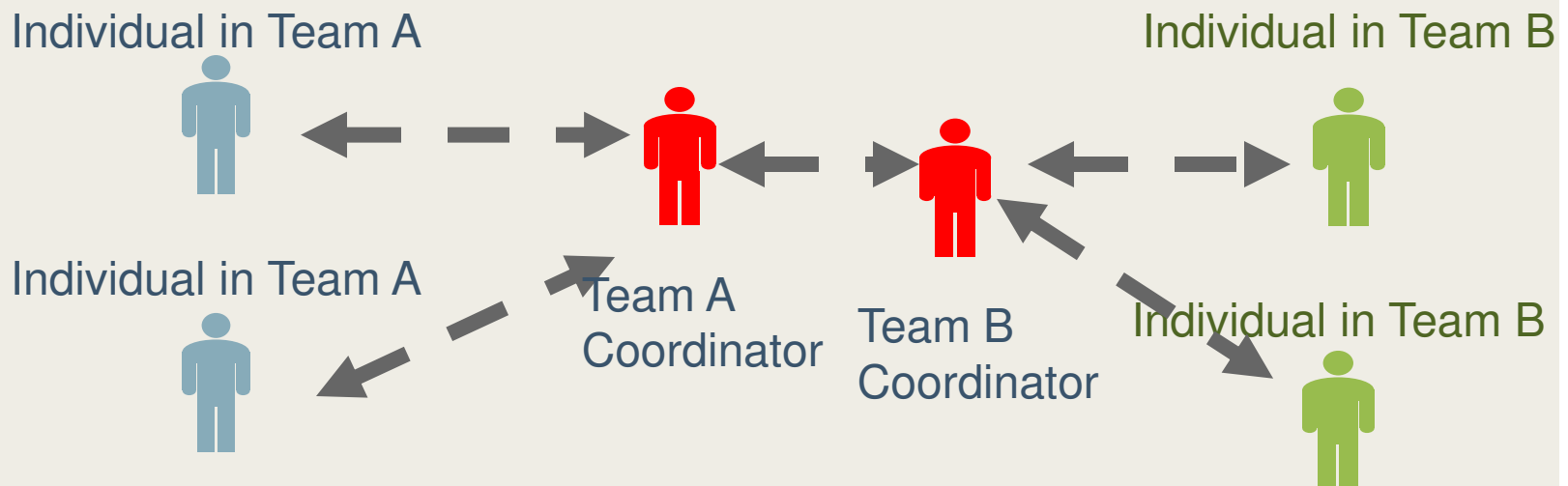
### Negatives:

- Potential loss of information
- Potential loss of time
- Unavailability of coordinator
- Coordinator may not have time to perform development.
- Coordinator may become a bottleneck
- Over time, interactions between Team A and Team B may lead to more understanding and reduced need for coordination.



## A->1 x 1<-B

Both teams have dedicated coordinator.  
Coordination path is member of Team A to Team A  
coordinator to Team B coordinator to member of Team  
B.





## A→1 x 1←B (continued)

### Positives:

- Team A coordinator may know answer and may not need to coordinate with Team B coordinator
- Team A coordinator is a member of Team A and internal coordination is easier than external coordination
- Coordination between Team A coordinator and Team B coordinator becomes easier because of the development of shared context.



## **A -> 1 x 1 <- B (continued – 2)**

### Negatives:

- Possible loss of information
- Possible loss of time
- Reduced development time for coordinators
- Coordinators may become bottlenecks
- Potential for loss of information is greater since information has to flow between more people



## Summary so far

Three different coordination models among two teams.

Hybrids are also possible, e.g. multiple coordinators, sub-team coordinators, rotating coordinators, etc.

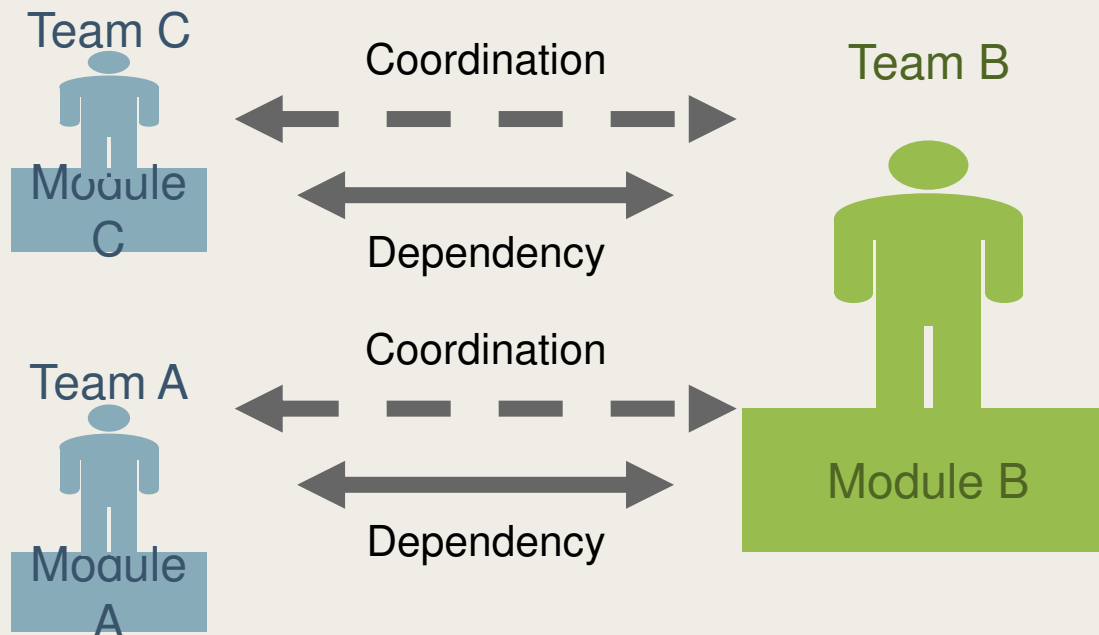
Organizations benefit from stability, i.e. constant coordinators, but also benefit from more knowledgeable individuals, i.e. rotating coordinators.

Trade off between project benefits and organizational benefits.



## Multiple Teams

Module dependencies are not necessarily 1-1.  
Suppose multiple modules (A & C) are using Module B  
Then teams A & C must coordinate with Team B.







## Generalization of base patterns

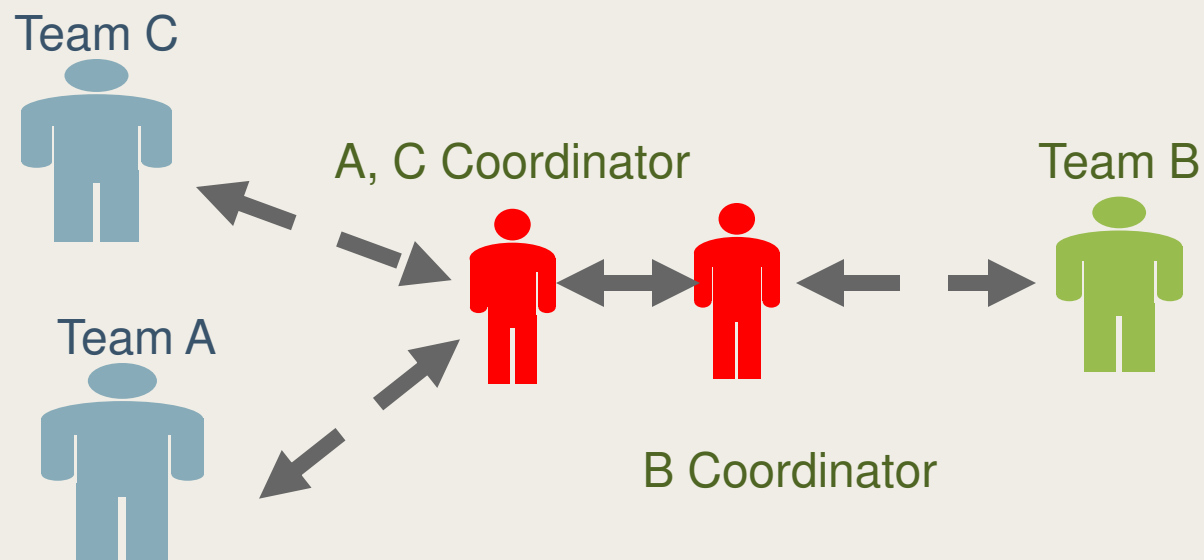
- $(A+C) \times B$  – each member of Team A and Team C coordinates individually with each member of Team B
- $(A+C) \times 1 \leftarrow B$  – each member of Team A and Team C coordinates with the coordinator for Team B
- $A \rightarrow 1 \times B \ \& \ C \rightarrow 1 \times B$  – each member of team B coordinates with the coordinator for Team A or the coordinator for Team C
- $A \rightarrow 1 \times 1 \leftarrow B \ \& \ C \rightarrow 1 \times 1 \leftarrow B$  - Each team A and C has a single individual who is responsible for coordination with Team B. The coordinator for Team B coordinates with both of these individuals.

These patterns also generalize to more than 2 modules that have a dependency on Module B.



## Another option (A+C)-> 1 x 1<-B

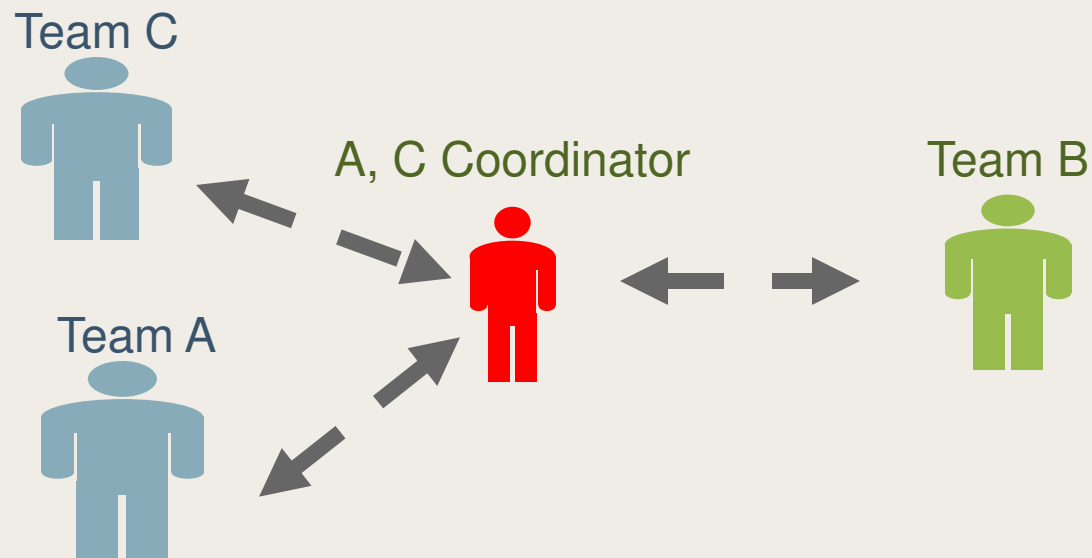
Place one individual in charge of managing coordination for Team A and Team C with the coordinator for Team B.





## Yet another option (A+C)-> 1 x B

Place one individual in charge of managing coordination with all of Team B for Team A and Team C.





## **Additional Options (continued)**

Now a single individual on the Team A and C side must coordinate with all members of both Team A and Team C.

Modifications to Module B may affect both Teams A and C

Requested modifications to Module B may be appropriate for only one of Teams A and C

These schemes requires coordination between Team A and Team C in how to approach Team B even though their modules are not dependent on each other. This is called “indirect coordination”.



## Coordination Notation

$\{\text{Set of Teams 1}\} \rightarrow \{\text{set of coordinators for those teams}\} \times$   
 $\{\text{set of coordinators for second set of teams}\} \leftarrow \{\text{set of Teams 2}\}$

- If one (or both) of the sets of coordinators are empty then leave out the corresponding  $\leftarrow$  or  $\rightarrow$ .
- An empty set of coordinators means that the coordination is directly with the team members.
- A coordination structure for a project is described using a collection of statements in this notation.
- It is possible for a team to occur in multiple statements since one member of a team may coordinate directly while others go through a coordinator.



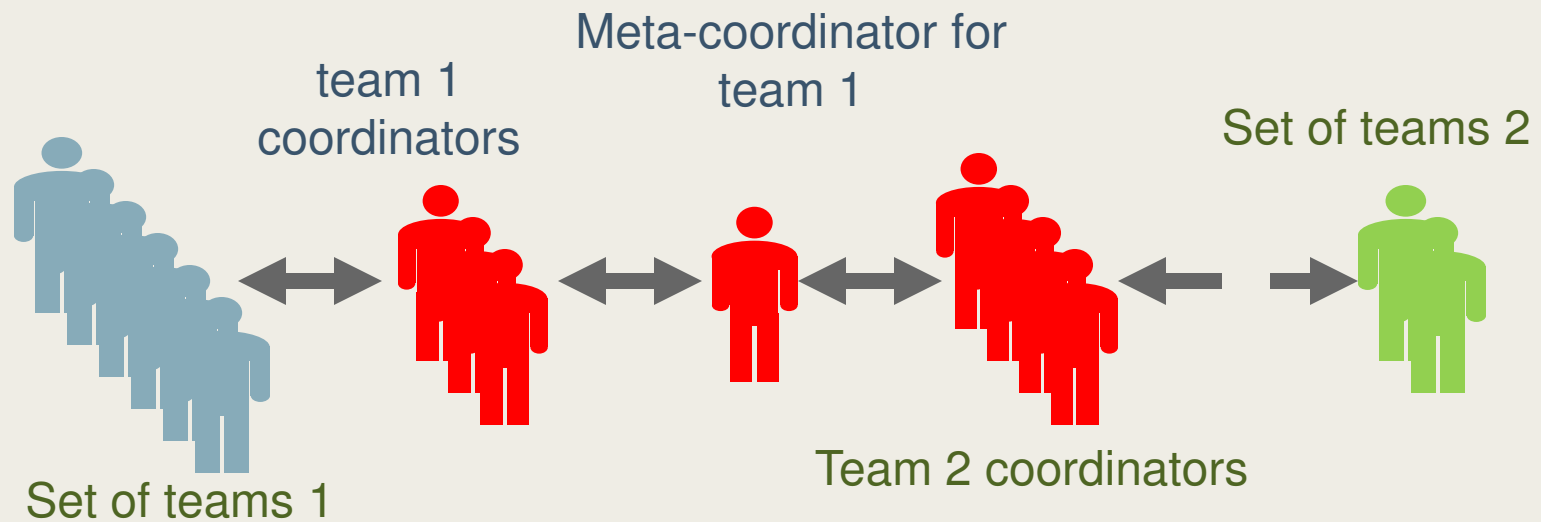
## **Coordination Notation - 2**

If there are fewer coordinators for a set of teams than there are teams, then there is a requirement for indirect coordination among the coordinators.



# Hierarchies of Coordination

It is possible that a set of coordinators coordinates with another set of coordinators through intermediaries.





## Notation for hierarchies

{set of teams 1} -> {set of coordinators for teams 1}->  
{set of meta coordinators for teams 1} x  
{set of coordinators for teams 2} <- {set of teams 2}





## What does the notation give us

The notation provides a common syntax to describe any coordination structure

Allows points of difference of coordination structures to be identified.

Provides a basis on which to discriminate different research results.

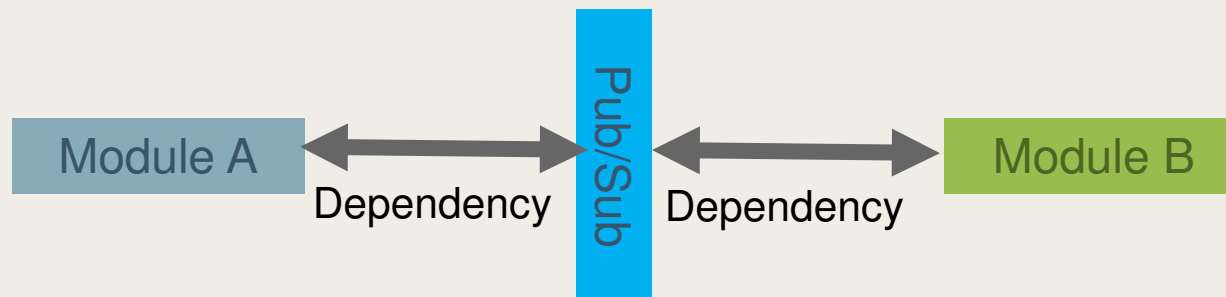
Haven't I forgotten

- Indirect dependencies?
- Timing issues?



## Indirect Dependencies

Dependencies can exist between modules even though they do not directly communicate. E.g. pub/sub. Module A and B communicate through an intermediary.





## **What are the coordination requirements for indirect dependencies?**

Team A must coordinate with the team developing the  
pub/sub module

Team B must coordinate with the team developing the  
pub/sub module

Team A must coordinate with Team B.

An indirect dependency is still a dependency.



## Timing issues

Consider the same pub/sub situation as previously and suppose that the realization that Module B will use the pub/sub mechanism occurs after development has begun.

Once Team B discovers the need to use the pub/sub mechanism, the dependency exists.

Dependencies may change over time but they can still be described using the syntax presented. The time varying nature of a particular dependency becomes a property of the description.



## Identifying dependencies

Dependencies must be correctly identified in order to understand the coordination requirements.

Dependencies can be discovered from

- Architectural documentation. The modules that are used by other modules can be partially identified from the documentation
- Examination of the code as it is developed.
- Team behavior during development. If a Team A member asks a question about Module B, then there is a potential coordination between Team A and Team B.
- Explicit identification by team members. The members of a team may know the modules on which they indirectly depend.



## Some research issues

How are dependencies discovered?

Goal is to choose a coordination model for a team that

- maximizes coordination with minimum cost or
- Increases chances of success or
- ...?

Need to describe the coordination structure (this is what this notation gives us)

Need to describe the coordination behavior – what is the correct notation for this?

Need to understand impact of environment. Environmental issues are

- Technology used to support the coordination
- Cultural factors



## Summary

The situation under consideration is after development has begun

If two modules have a dependency they must coordinate.

I presented a notation for describing a coordination structure for a project.

The choice of a coordination structure will depend on a variety of factors yet to be determined.



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# Questions?

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