No.85

Design and Evaluation of Project Organization based on Communication Links

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Nobuaki Ishii, Kanagawa University, Japan
Masaaki Ohba, Nihon University, Japan

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Background & Motivation

- Project is <u>a temporary work</u> undertaken by <u>a temporary organization</u> to create a unique product, service, or result.

- Communication among project organization is a key for the project success.

  ➔ Especially when the organization includes external entities, like joint venture partners, subcontractors.
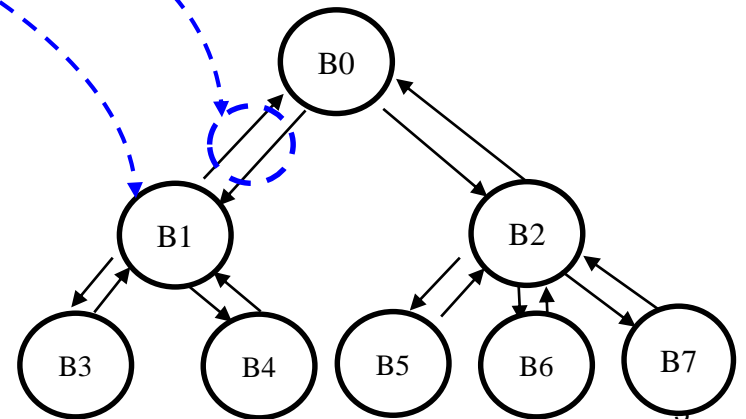
Objectives

In this presentation, we present
A method of design and dvaluation of
project organization based on
<u>Communication Links</u> including external
<u>entities</u>.

A structure of the
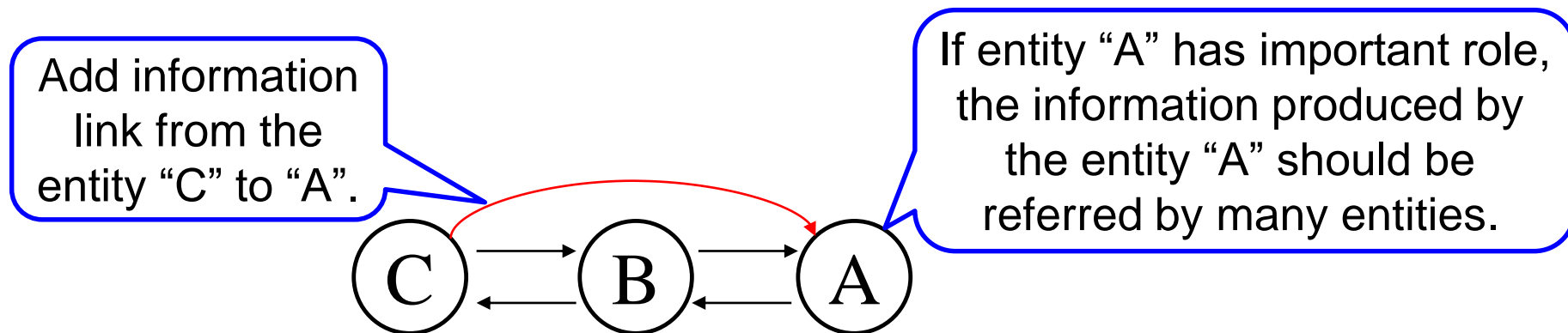communication links in
Project Organization

The communication links
are <u>channels or pathways</u> through
which entities can communicate,
access and distribute information.

Assumption

The information created by the entity playing a more important role in the project has higher value,

The information created by each entity should be referred to in accordance with the value of information.

Add information link from the entity "C" to "A".

If entity "A" has important role, the information produced by the entity "A" should be referred by many entities.

C → B → A

A structure of communication links among organization

Evaluation of the structure of the communication links in a project organization

Overview of the evaluation method

Assumption

The rate of its information referred by other entities must be proportional to the value of information produced by the entity.

Rate of its own information referred by other entities (RIR)

$\propto$

Value of information produced by each entity (VIE)

R representing RIR

POA: Project Organization Assessment

Evaluation Index POA
$= |R - V|$

V representing VIE

Calculating the rate of its own information referred to by other entities (RIR)

Eigen vector **R** of matrix **Q** is used as the value of RIR including informal communication links.

➔ Similar idea of Ranking Web Page by using a transition matrix

$$Q = \alpha\, M + (1 - \alpha)\, N\,(O - I)$$

$$R = c\, Q\, R$$

R: Eigenvector of the matrix **Q** representing the structure of information links,

Q : A square matrix representing the structure of communication links including informal communication.

M : A square matrix representing the structure of communication links without informal communication,

N, O, I = A square matrices to identify companies of joint venture.

α : Scaling parameter between 0.0 to 1.0 representing the rate of formal communication among entities.

Calculating the value of information created by each entity (VIE)

Evaluating VIE is <u>a decision making problem </u>which provides scores to the entities in the order of importance.

Determining VIE is a complex and multi-criteria decision problem to be examined in consideration of <u>several factors, such as resource availability, technical feasibility, lead-time, and so on</u>.
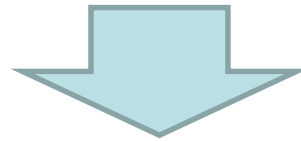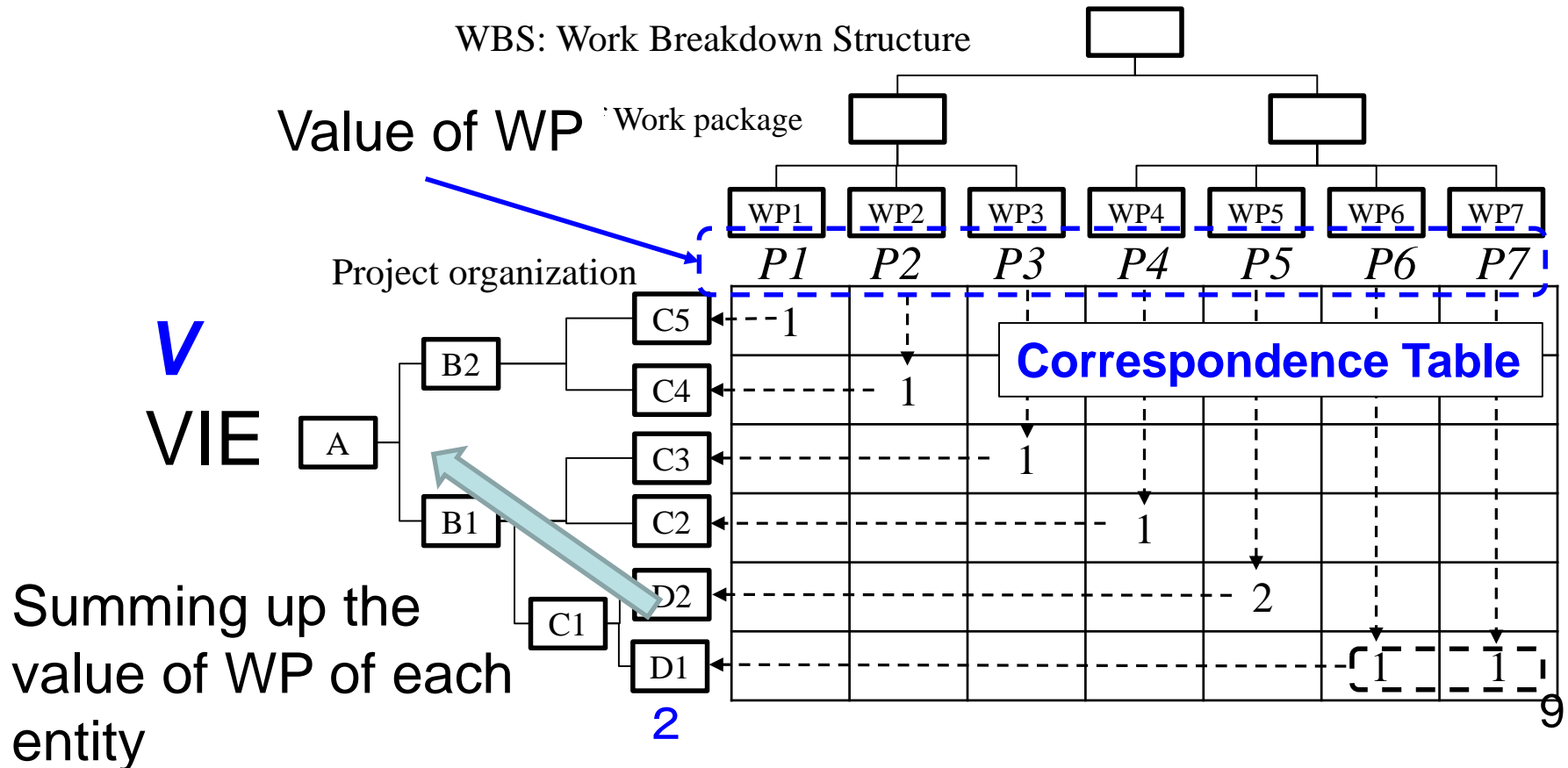
The value of the <u>Work Package </u>(WP) carried out by the entity can be defined as proportional to the value of information produced by each entity.

WP based methodology for determining VIE.

Example of WP based VIE

✓ WP is the lowest level of the Work Breakdown Structure (WBS) .

✓ VIE is calculated as a vector **V** based on the value of WP of each entity using the corresponding table.

WBS: Work Breakdown Structure

Value of WP — Work package

Project organization

V
VIE

Summing up the value of WP of each entity

	P1	P2	P3	P4	P5	P6	P7
C5	1						
C4		1					
C3			1				
C2				1			
D2					2		
D1						1	1

Correspondence Table

A
B2
B1
C1
2

Evaluation index (POA: Project Organization Assessment)

✓ Evaluation index POA <u>indicates the difference between **R** and **V**</u> of each entity.

✓ POA is calculated as the norm between **R** and **V**.

✓ POA=0 indicates the ideal structure of communication links in organization.

$$POA = \mid R - V \mid = \sqrt{\sum_{i=1 \sim n}(r_i - v_i)^2}$$

- **R:** Eigenvector of the matrix **Q** representing the structure of communication links.
- **V** : Vector of the relative value of information produced by each entity i in organization.
- r_i : Element of **R**, $r_i \geqq 0.0$, $\Sigma_{i=1,n}\, r_i = 1.0$
- v_i : Element of **V**, $v_i \geqq 0.0$, $\Sigma_{i=1,n}\, v_i = 1.0$.
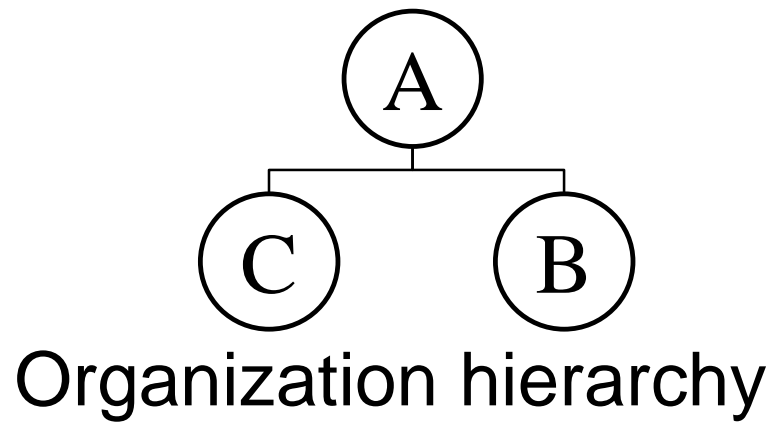- n is the total number of CS entity.

A method
of
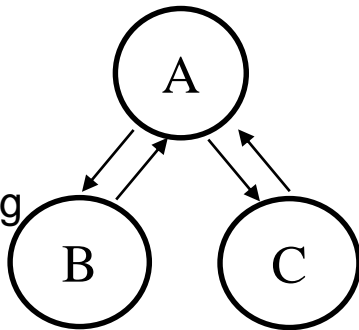# project organization design based on the communication links

Present a design method, which searches a structure of the communication links that minimizing the index POA.

First stage: Create an initial structure of communication links.

A

C   B

Organization hierarchy

Binominal communication links are determined among entities.

A

B   C

Create a structure of communication links based on the organization hierarchy

Matrix **Q** representing the structure

$$\begin{array}{c@{\quad}ccc} & A & B & C \\ A & \begin{pmatrix} 0 & 17/20 & 17/20 \\ B & 1/2 & 0 & 3/20 \\ C & 1/2 & 3/20 & 0 \end{pmatrix} \end{array}$$

$$Q = \alpha\, M + (1 - \alpha)\, N\, (O - I)$$
$$\alpha = 0.85$$

Rate of formal communication among entities

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Second stage: Modify initial communication links to make POA smaller

Step 1: Calculate the POA index of the initial structure of the communication links created in the first stage.

Step 2: Attempt to search the structure of the communication links that makes POA index as small as possible by applying the following heuristic rules repeatedly.

R1: Modify *R* by changing the relative importance of communication links

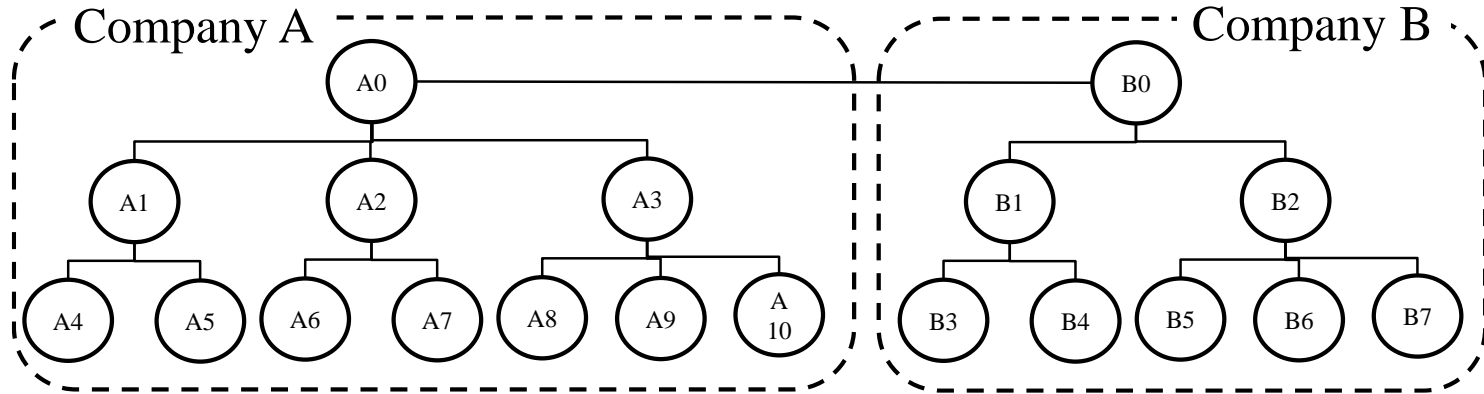R2: Modify *R* by adding a new link from the lower rank entity in the project organization hierarchy

R3: Modify *V* by changing the work packages carried out in each entity.

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Numerical examples

Problem Setting

Example joint venture formation (Formal reporting lines of the)

Cases of numerical examples

| Case	Description
Case 0	Initial structure of communication links.
Case 1	Relative importance of communication links of Case 0 is modified by the heuristic rule R1.
Case 2	Structure of communication links of Case 1 is modified by the heuristic rule R2.
Case 3	Structure of communication links of Case 2 is modified by the heuristic rule R3.

Problem Setting

Correspondence Table (Case 0, Case 1, Case 2)

Process		Design					Procurement				Construction					
Work package		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Lowest entity in organization	A4		1														
	A5	1															
	A6								1	1							To be changed in Case 3
	A7						1	1									
	A8												1				
	A9											1					
	A10										1						
	B3	1			1												
	B4			1		1											
	B5											1				1	
	B6														1		
	B7													1			

Numerical examples

Case 0: Initial structure of the communication links

POA=0.423

Company A — Company B
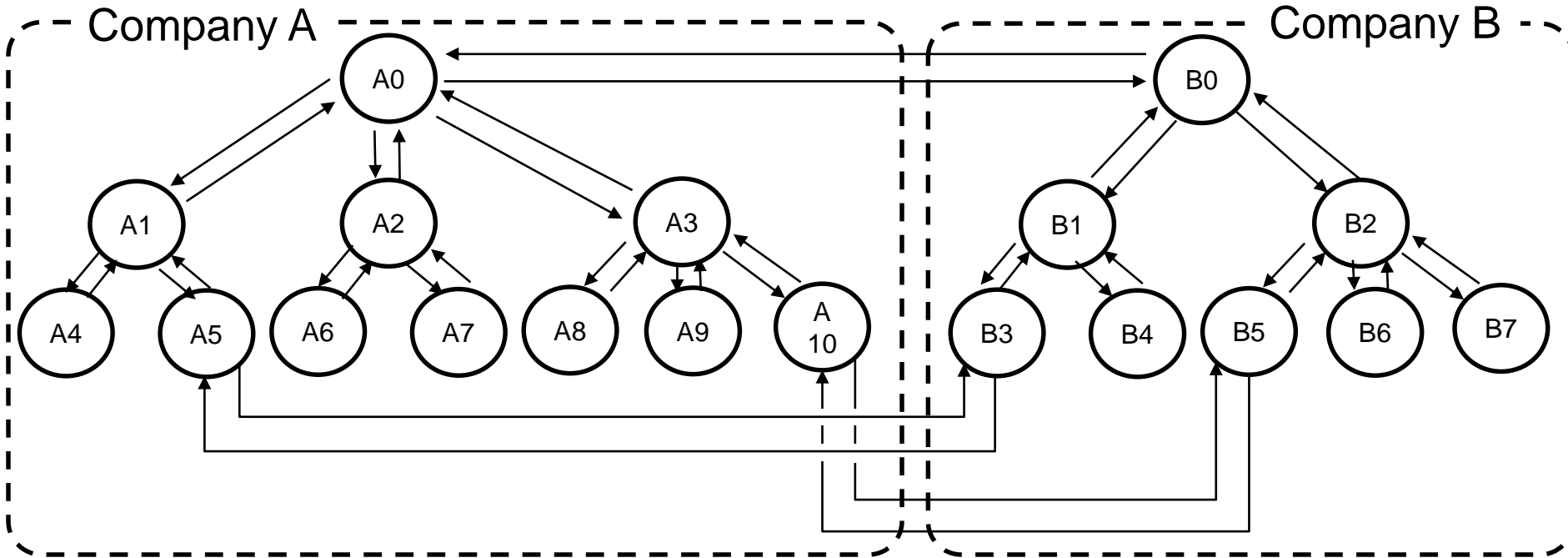
- <u>The bidirectional communication links</u> are determined between entities of each formal reporting line.
- If more than two entities are assigned to a work package, binominal communication links are added among those entities.

Case 0: Modified Communication Matrix *Q*

	A0	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	B0	B1	B2	B3	B4	B5	B6	B7
A0	0	0.3	0.3	0.23	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.28	0	0	0	0	0	0	0
A1	0.23	0	0.02	0.02	0.87	0.44	0.02	0.02	0.02	0.02	0.02	0	0	0	0	0	0	0	0
A2	0.23	0.02	0	0.02	0.02	0.02	0.87	0.87	0.02	0.02	0.02	0	0	0	0	0	0	0	0
A3	0.23	0.02	0.02	0	0.02	0.02	0.02	0.02	0.87	0.87	0.44	0	0	0	0	0	0	0	0
A4	0.02	0.3	0.02	0.02	0	0.02	0.02	0.02	0.02	0.02	0.02	0	0	0	0	0	0	0	0
A5	0.02	0.3	0.02	0.02	0.02	0	0.02	0.02	0.02	0.02	0.02	0							
A6	0.02	0.02	0.3	0.02	0.02	0.02	0	0.02	0.02	0.02	0.02	0							
A7	0.02	0.02	0.3	0.02	0.02	0.02	0.02	0	0.02	0.02	0.02	0	0	0	0	0	0	0	0
A8	0.02	0.02	0.02	0.23	0.02	0.02	0.02	0.02	0	0.02	0.02	0	0	0	0	0	0	0	0
A9	0.02	0.02	0.02	0.23	0.02	0.02	0.02	0.02	0.02	0	0.02	0	0	0	0	0	0	0	0
A10	0.02	0.02	0.02	0.23	0.02	0.02	0.02	0.02	0.02	0.02	0	0	0	0	0	0	0.43	0	0
B0	0.21	0	0	0	0	0	0	0	0	0	0	0	0.3	0.23	0.02	0.02	0.02	0.02	0.02
B1	0	0	0	0	0	0	0	0	0	0	0	0.3	0	0.02	0.45	0.87	0.02	0.02	0.02
B2	0	0	0	0	0	0	0	0	0	0	0	0.3	0.02	0	0.02	0.02	0.45	0.87	0.87
B3	0	0	0	0	0	0.43	0	0	0	0	0	0.02	0.3	0.02	0	0.02	0.02	0.02	0.02
B4									0	0	0	0.02	0.3	0.02	0.02	0	0.02	0.02	0.02
B5									0	0	0.43	0.02	0.02	0.23	0.02	0.02	0	0.02	0.02
B6									0	0	0	0.02	0.02	0.23					0.02
B7	0	0	0	0	0	0	0	0	0	0	0	0.02	0.02	0.23	0.02	0.02	0.02	0.02	0

Company A

Company B

Communication links from Company B to A

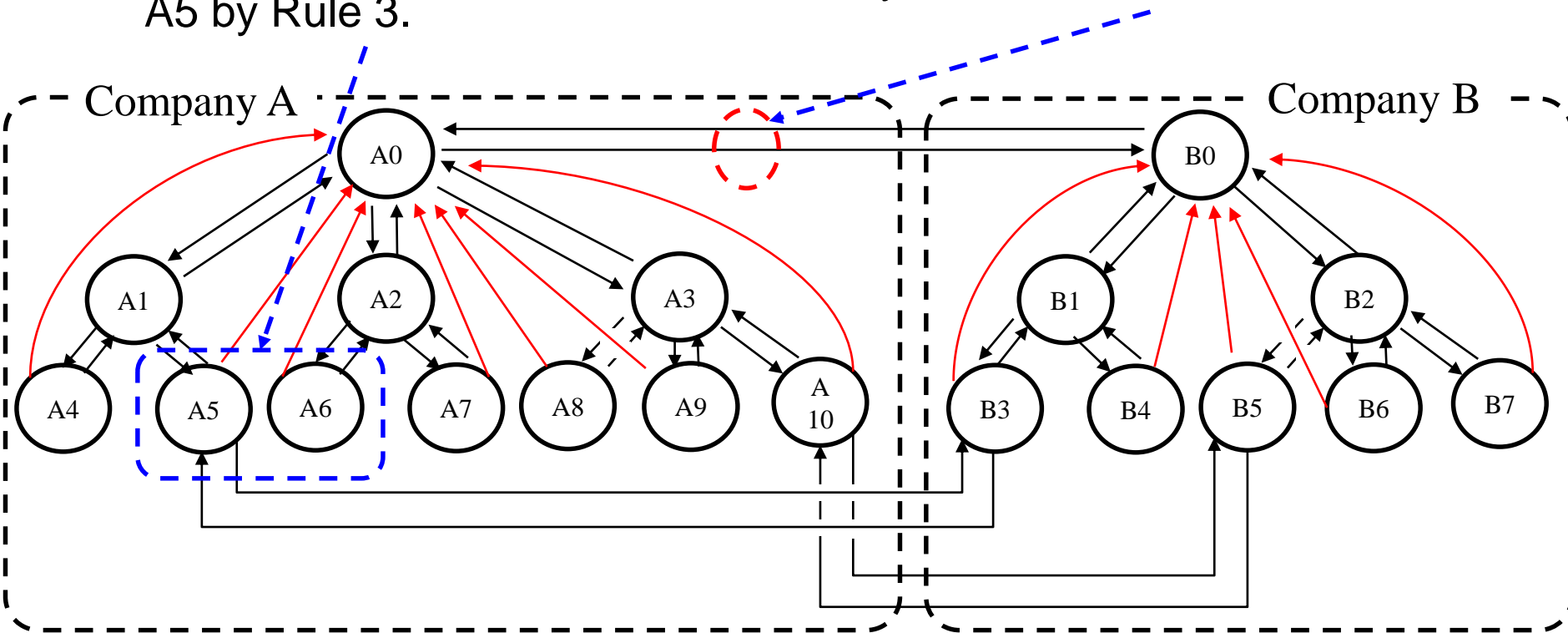Communication links from Company A to B

$$Q = \alpha\, M + (1 - \alpha)\, N\,(O - I)$$

Numerical examples

Evolution of the initial structure of communication links by heuristic rules.

Case 3: Assignment of WP9 is changed from entity A6 to A5 by Rule 3.

Case 1: The relative importance between A0 and B0 are changed by Rule 1.

New communication links added by Rule 2 in Case 2

Numerical examples

POA: Improved by applying heuristic rules

Case 1: The relative importance between A0 and B0 are changed by Rule 1.

Case 2: New links to A0 and B0 from the lower rank entity are added by Rule 2.

Case 3: Assignment of WP9 is changed from entity A6 to A5 by Rule 3.

POA index

0.5

0.4

0.423

0.3

0.376

0.2

0.1

0.167

0

0.120

Case 0   Case 1   Case 2   Case 3
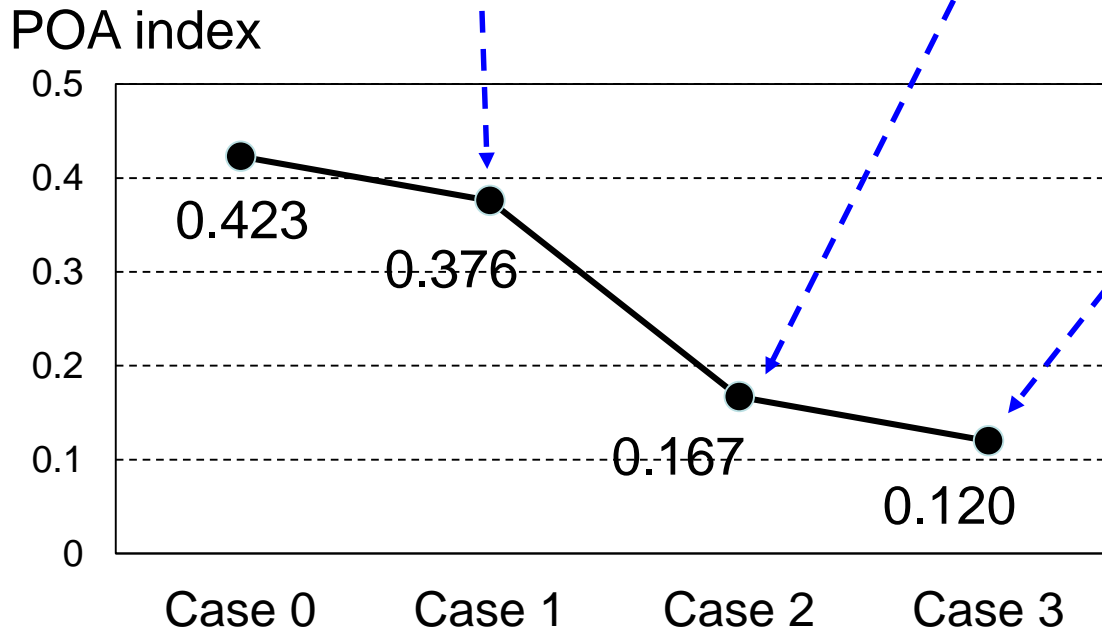
The design method searches the structure of the information links that makes POA smallest among Cases.

Conclusions

- ✓ <u>A method of design and evaluation of project organization</u> based on the structure of the communication links is developed.

- ✓ <u>The performance of the design method</u> is demonstrated via numerical experiments using a simple project organization model.

Further investigations

- ✓ The method that integrates diverse factors, such as cost, risk, technical feasibility, and so on, should be developed.

- ✓ The heuristic rules to search the appropriate structure of communication links and an algorithm to apply the rules effectively should be developed.

Thank you for your attention.