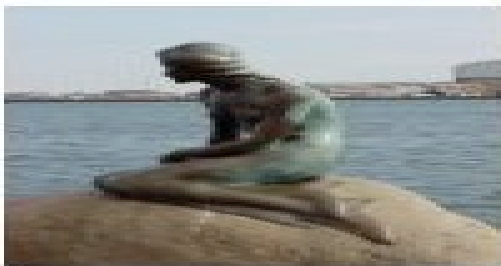


Non-Unit Based Planning and Scheduling of Repetitive Construction Projects

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Outlines

- Introduction
- The “Non-Unit” Based Repetitive Projects
- Research Objectives
- Literature Reviews
- Development of the Non-unit Based Scheduling Algorithm
- A Simple Case Study
- Conclusions

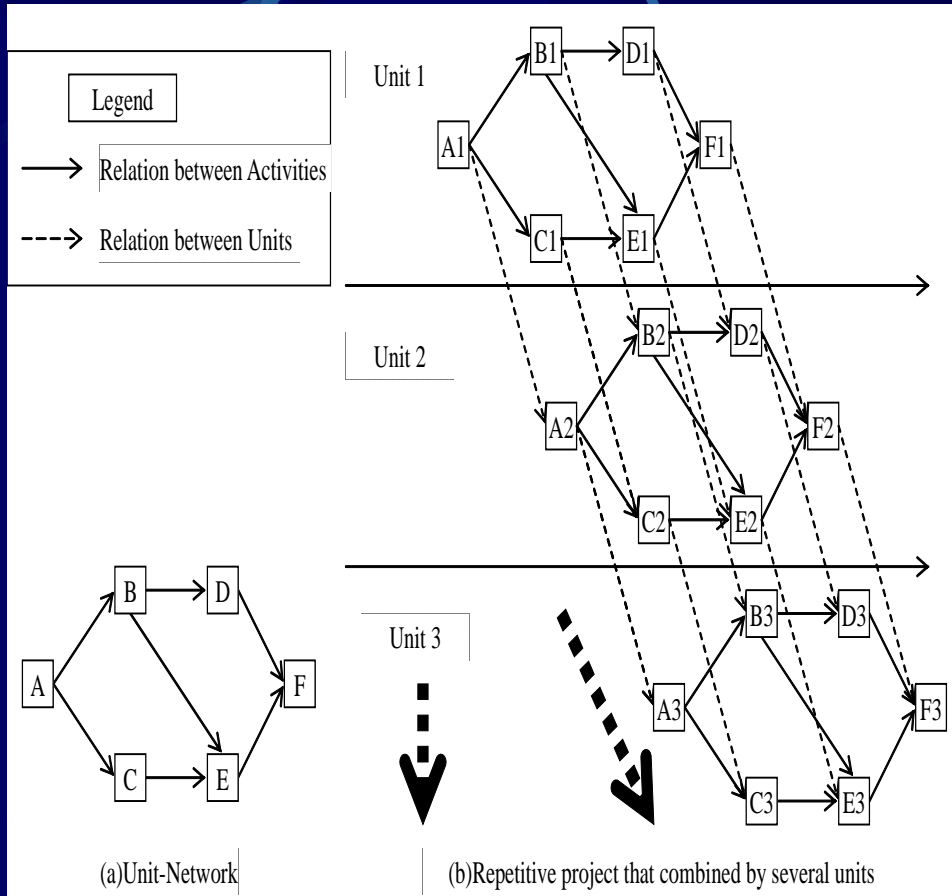
Introduction

- One of the major goals of lean construction is for waste reduction.
- Repetitive construction projects are good candidate for applying the lean construction principles.
- Almost all the repetitive scheduling methods developed are based on the primitive that a repetitive project is the construction of many identical production units

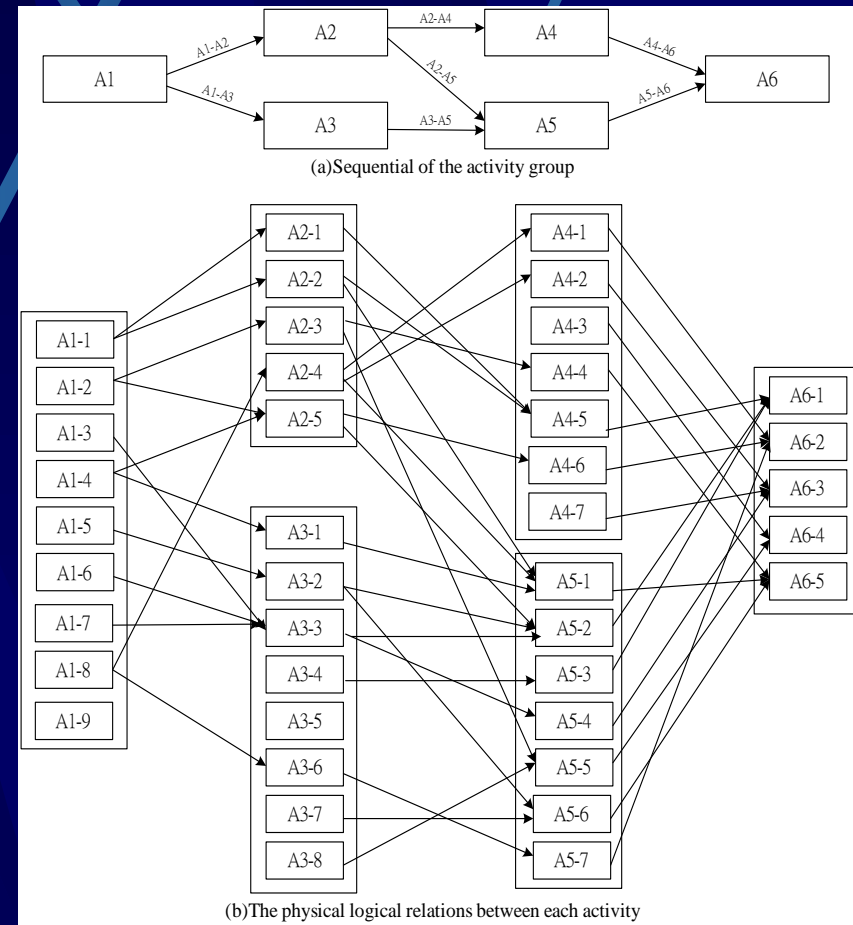
Introduction (cont.)

- In practical, however, the production units in many repetitive projects may not be identical.
 - In a piling project, the excavation depth and the encountered soil conditions for each pile;
 - In a pipeline-laying project, the number of manholes and the number of pipe sections, also the durations for laying each pipe
 - In a multi-housing project, the interior design for each house could be different, and therefore the required work load as well as the duration and cost will differ
- Many repetitive projects contains, more or less, portions of non-repetitive productions.

- Unit based repetitive projects



- Non-unit based repetitive projects



Characteristics of a Non-unit Based Repetitive Project

- The operations of activities in an activity group are similar, but not the same.
- The work logical relationships are more generalized.
- There is no hard logic relationship between activities in the same activity group.
- Various working crews can be employed in each activity group.
- Cost and time for routing the various resource crews among production units are considered.

Research Objectives

Develop a non-unit based scheduling algorithm:

- to comply with the logical relationship of activity groups in a repetitive project,
- to allow for the usage of various resource crews in an activity group,
- to maintain the continuity for resource usage, and
- to consider the time and cost for change over of various resource crews in job.

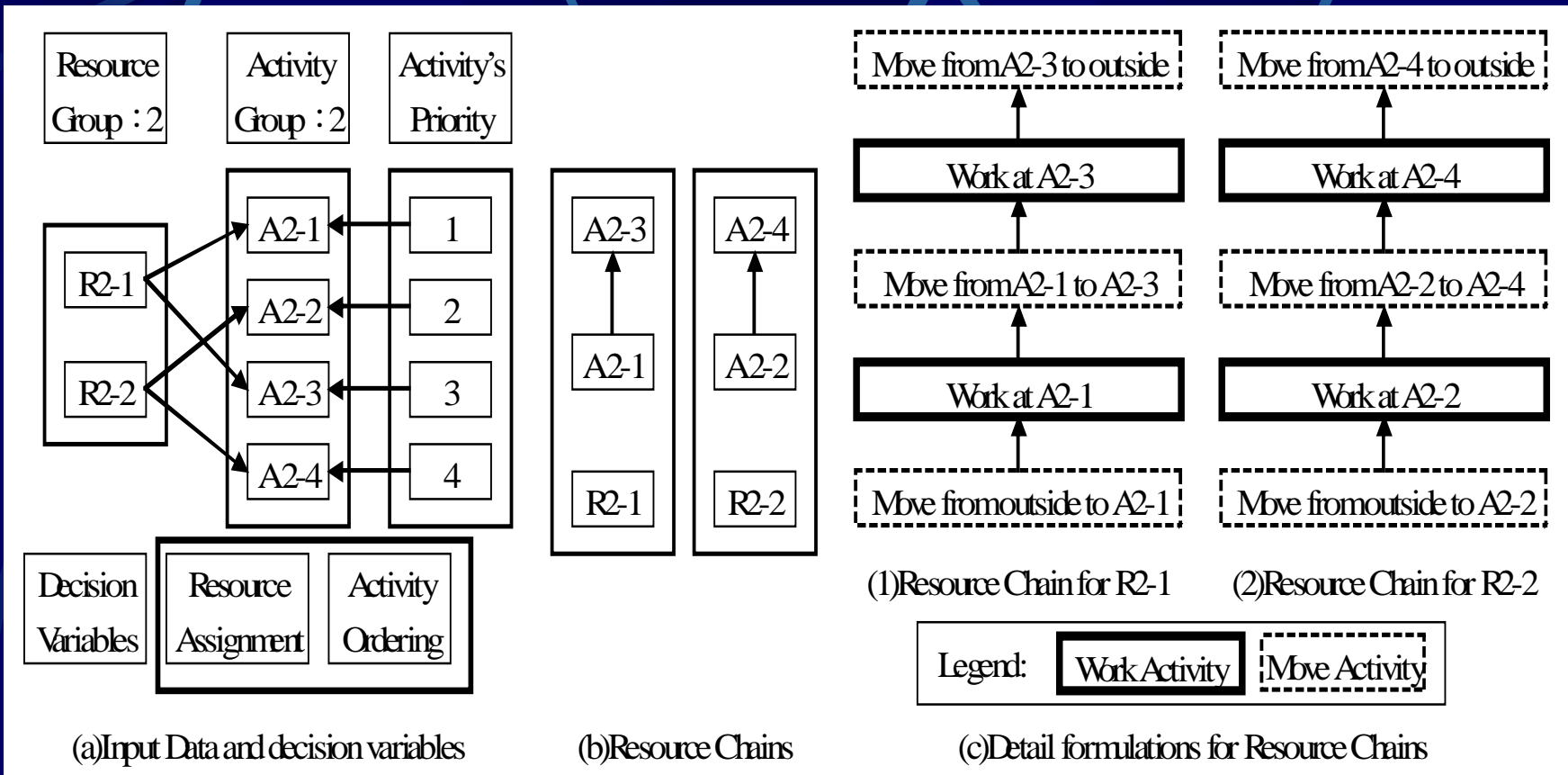
Literature Reviews

Author (s) (1)	Method (2)	Unit-based (3)	Fixed work sequence (4)	Non-typical activity (5)	Assign multiple resource types in a workgroup (6)	Resource continuity (7)
Carr and Meyer(1974)	LOB	Y	Y	N	N	Y
O'Brien (1975)	VPM	Y	Y	N	N	Y
Selinger (1980)	Const. planning	Y	Y	Y	N	Y
Johnston (1981)	LSM	Y	Y	Y	N	Suggested
Stradal and Cacha (1982)	Time space scheduling	Y	Y	Y	N	Suggested
Arditi and Albulak (1986)	LOB	Y	Y	N	N	Y
Chrzanowski and Johnston (1986)	LSM	Y	Y	Y	N	Y
Reda (1990)	RPM	Y	Y	N	N	Y
El-Rays and Moselhi (1998)	Resource-driven scheduling	Y	N	Y	N	N
Harmelink and Rowings (1998)	Linear scheduling model	Y	Y	N	N	Y
Harris and Ioannou (1998)	RSM	Y	Y	Y	N	N
Hegazy and Wassef (2001)	Repetitive nonserial activity scheduling	Y	Y	N	N	N

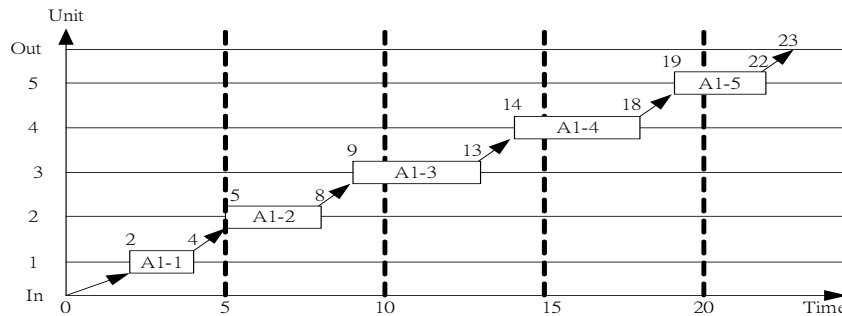
Steps of Algorithm

- Identify Activity Groups as well as their sequence relationships
- Develop the Resource Chains
- Place Resource Chains for Project Scheduling
 - Calculate the baseline schedule
 - Calculate the earliest possible start time of each activity
 - Determine the earliest possible start time of resource chain
 - Calculate the project schedule of the resource chain

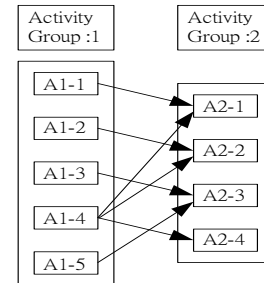
Illustration of Resource Chain Development



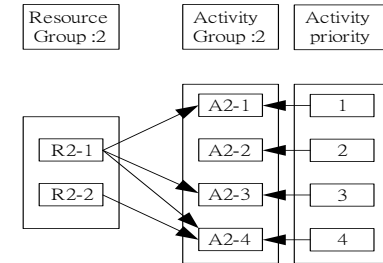
Placing of Resource Chains



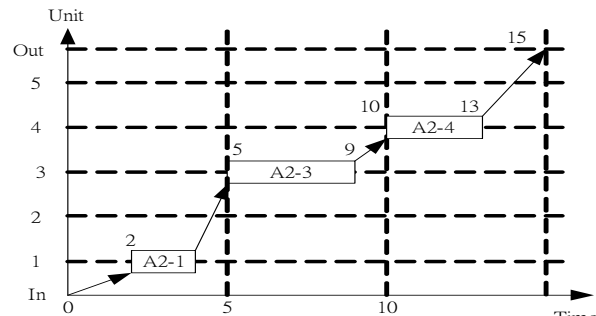
(a) Precedence Resource Chain on Project Schedule



(b) Activity Logic Relation



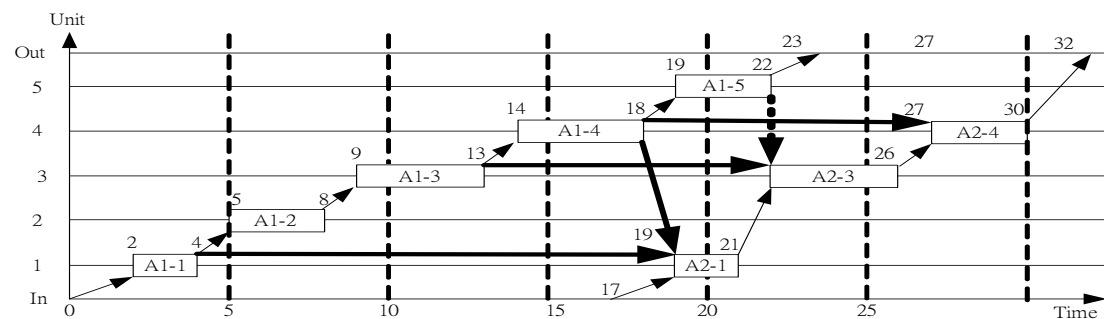
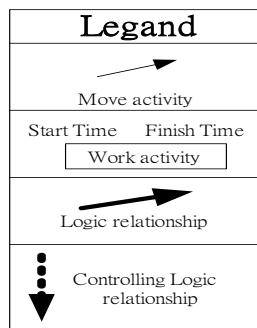
(c) Resource and priority assignment



(d) R2-1 Resource Chain on Baseline Schedule

(1)	Activity	In-> A2-1	A2-1	A2-1-> A2-3	A2-3	A2-3->A2-4	A2-4	A2-4->Out	
(2)	Duration	2	2	1	4	1	3	2	
(3)	Baseline schedule	Start time	0	2	4	5	9	10	13
		Finish time	2	4	5	9	10	13	15
(4)	Precedence activity		A1-1,A1-4		A1-3,A1-5		A1-4		
(5)	Last finish time for precedence activity		Max(4,18)=18		Max(18,22)=22		18		
(6)	Calculate the possible start time for the resource chain		18-2=16		22-5=17 (Max)		18-10=8		
(7)	Total project schedule	Start time	17	19	21	22	26	27	30
		Finish time	19	21	22	26	27	30	32

(e) Calculation Table for positioning R2-1 Resource Chain from Baseline Schedule to total project schedule

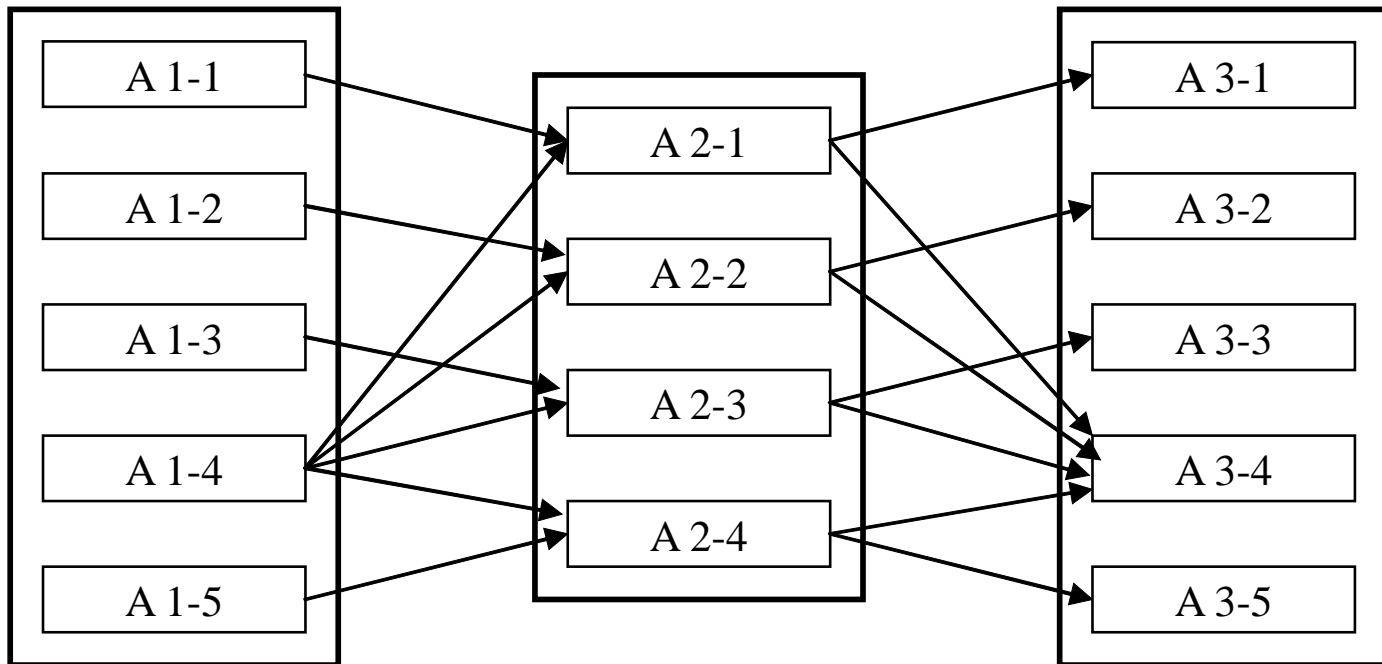


(f) Positioning Current Resource Chain into total Project Schedule

A Simple Case Study



(a) Sequential of the activity group



(b) The physical logical relations between each activity

Activity Groups Data

Activity group	No. of Activity	Pre-group	Resource Types Used	Resource code
A1	5	-	1	R1-1
A2	4	1	2	R2-1? R2-2
A3	5	2	1	R3-1

Activity Data

Activity Group 1	Precedence Activity	Activity Group 2	Precedence Activity	Activity Group 3	Precedence Activity
A1-1	-	A2-1	A1-1? A1-4	A3-1	A2-1
A1-2	-	A2-2	A1-2? A1-4	A3-2	A2-2
A1-3	-	A2-3	A1-3? A1-4	A3-3	A2-3
A1-4	-	A2-4	A1-4? A1-5	A3-4	A2-1? A2-2? A2-3? A2-4
A1-5	-			A3-5	A2-4

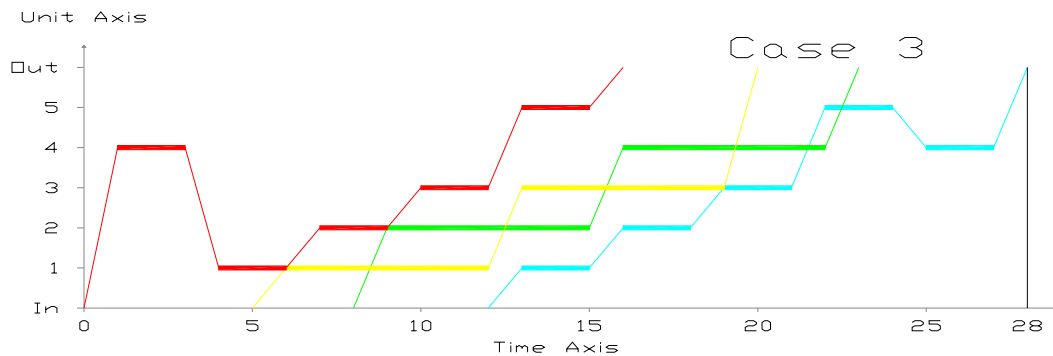
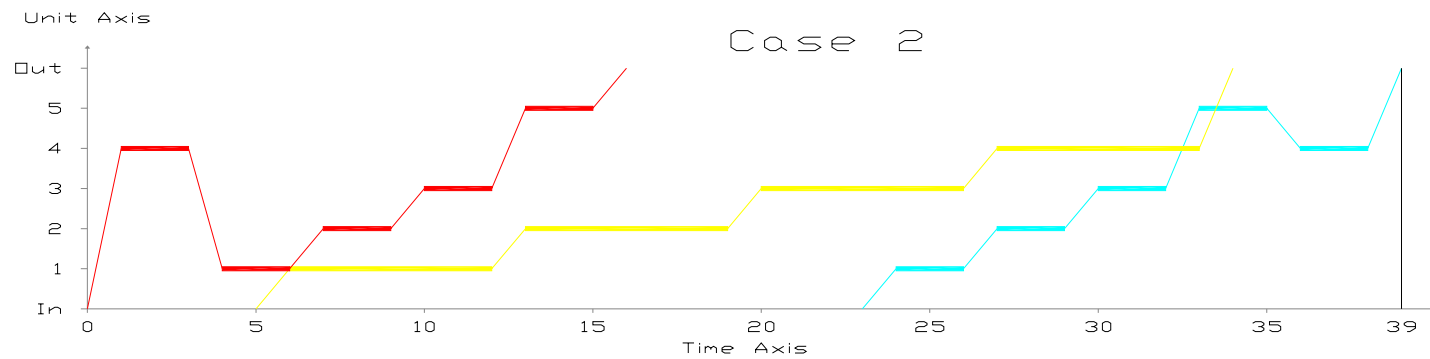
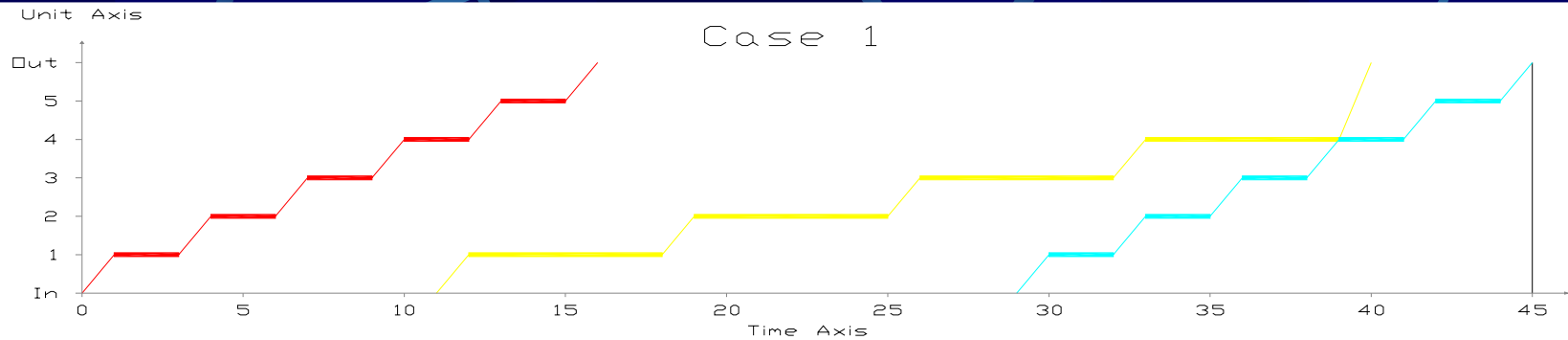
Duration Data For Routing Resource (R1-1)

	->	To Activity					
		Out	1-1	1-2	1-3	1-4	1-5
From Activity	In	-	1	1	1	1	1
	1-1	1	2	1	1	1	1
	1-2	1	1	2	1	1	1
	1-3	1	1	1	2	1	1
	1-4	1	1	1	1	2	1
	1-5	1	1	1	1	1	2

Testing Scenarios

- Scenario 1 : Only one resource type is used for each work group. As a result, only R2-1 is used for activity group 2.
- Scenario 2 : The operating priority of activity A1-4 is moved to the highest, and that of activity A3-4 to the lowest. The rest of input data is the same as those in Scenario 1.
- Scenario 3 : One more resource, R2-2, is employed for the operation in activity group 2. The rest of input data is the same as those in Scenario 2.

Scheduling Results



Notation	
—	Task Group:1 Resource No:1-1
—	Task Group:2 Resource No:2-1
—	Task Group:2 Resource No:2-2
—	Task Group:3 Resource No:3-1

Conclusions

- Non-unit based scheduling provides a more general form for planning and scheduling of repetitive projects,
 - activities in an activity group are similar, but not the same.
 - no hard logic relationship between activities in the same activity group.
 - working crews with same or different construction methods can be employed in each activity group.

Conclusions (cont.)

- Cost and time for routing the various resource crews among activities are considered in the developed algorithm.
- The non-unit based algorithm represents more closely the real word practices of repetitive projects
- Method for optimization of the non-unit based scheduling can be further developed in the future

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