Advanced Topics of Software Engineering (ASE)

Chapter 2. From requirements to system design

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From requirements to system design

Dependency structure matrix (DSM)

A two-dimensional matrix representing the structural or functional interrelationships of objects, tasks or teams

- Support for modelling dependency in large software architectures
- Dependencies between different parts of the software can be presented in a matrix form

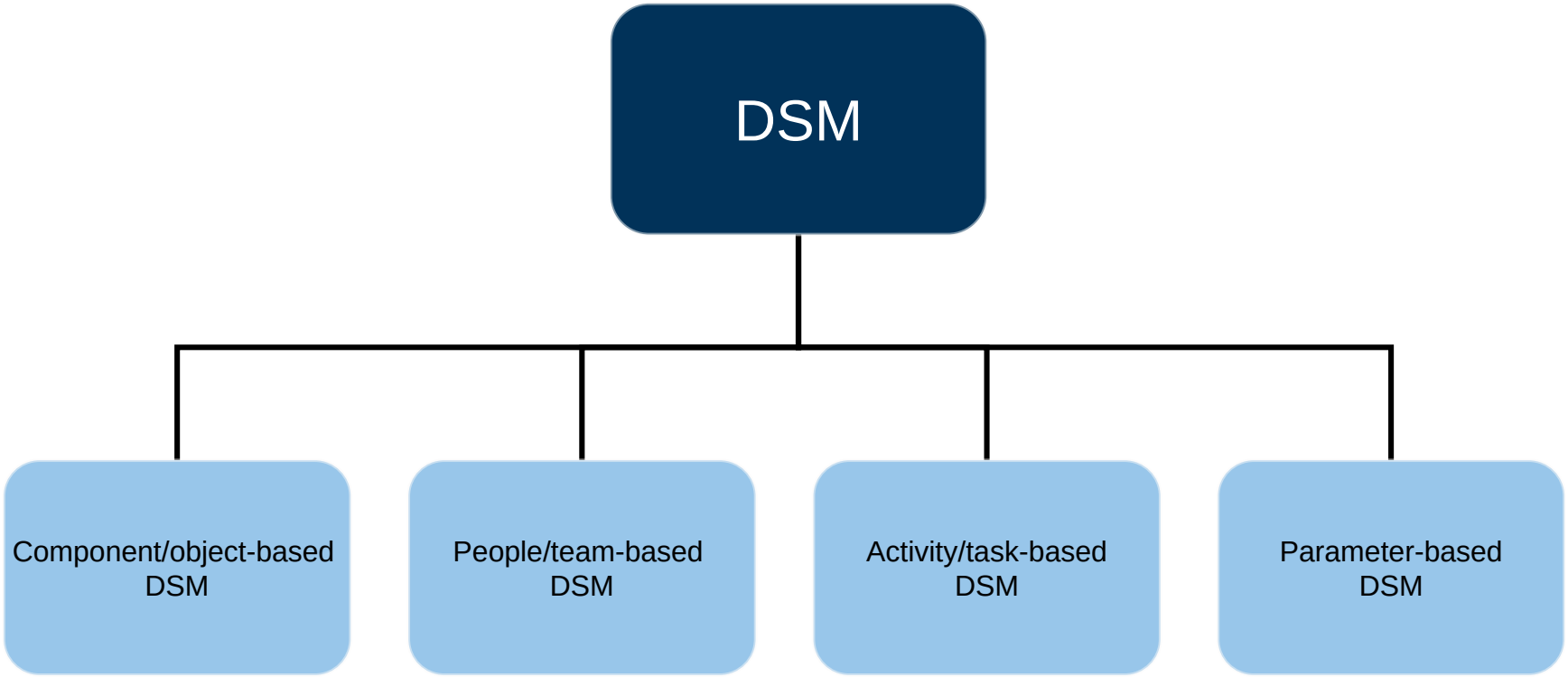
- In a DSM the items being analyzed make up the rows and columns of a two-dimensional matrix

An entry in the matrix indicates that the item on the corresponding column depends on the item on the corresponding row

- Also known as (depending on the context of application)
  - design structure matrix
  - dependency structure method
  - dependency source matrix
  - problem solving matrix (PSM)
  - incidence matrix
  - N2matrix
  - interaction matrix
  - dependency map
  - design precedence matrix

["Using dependency models to manage complex software architecture." Sangal et al. (2005)]

Categorization of DSM



A simple DSM

	A	B	C	D
A	-		X	X
B		-	X	
C	X		-	X
D				

- A depends on C
- C depends on A and B
- D depends on A and C
- B does not depend on any of them

Column depends on rows

- This DSM is binary
  - Shows if there is dependency between two items
- All dependencies are of equal weight
  - The crosses (X) can be replaced with numbers that show the exact dependency weights

Block triangular DSM after partitioning

	D	A	C	B
D	-			
A	X	-	X	
C	X	X	-	
B			X	

- A and C are mutually dependent
- A and C can be regarded as a single *composite* entity (component/task)
- This transformation is known as ***partitioning***
- A DSM which has been rearranged so that all dependencies either fall below the diagonal or within groups, is said to be in ***block triangular*** form

Lower triangular DSM

	D	A-C	B
D	-		
A-C	X	-	
B		X	-

- Ensures dependency relations are acyclic
  - No entries above the diagonal
- By considering A and C as a single composite task, the cycle can be eliminated

Hierarchical DSM

		D	A	C	B
D		-			
A-C	A	X	-	X	
	C	X	X	-	
B				X	

- Introduces hierarchical structure
- Identities of the basic entities (components/tasks) can be retained
- The grouping of A and C is shown by their indentation

Detecting patterns in DSM

Layered software systems

$root			1	2	3	4	5
org.example	application	1	-				
	model	2	X	-			
	domain	3	X	X	-		
	framework	4	X	X	X	-	
	util	5	X	X	X	X	-

["Using dependency models to manage complex software architecture." Sangal et al. (2005)]

Detecting patterns in DSM

Strictly layered software systems

$root			1	2	3	4	5
org.example	application	1	-				
	model	2	X	-			
	domain	3		X	-		
	framework	4			X	-	
	util	5				X	-

["Using dependency models to manage complex software architecture." Sangal et al. (2005)]

Detecting patterns in DSM

Layered system example - *JUnit*

			1	2	3	4	5	6
junit	awtui	1	-					
	swingui	2		-				
	textui	3			-			
	extensions	4		1		-		
	runner	5	3	8	4		-	
	framework	6	5	7	6	6	5	-

- Junit version 3.8.1
- Layered system with clean separation of the user interface layers from the underlying core logic
- Notice the numbers: they indicate the number of dependencies

["Using dependency models to manage complex software architecture." Sangal et al. (2005)]

Detecting antipatterns in DSM

Too many dependencies?

$root			1	2	3	4	5	6
org.example	artifact-test	1	-					
	core	2		-				
	project	3		X	-			
	artifact-manager	4		X	X	-		
	reporting-api	5		X			-	
	model	6		X	X		X	-

Detecting antipattern in DSM

Change propagator

$root			1	2	3	4	5	6	7	8	9	10
org.example	actions	1	-								X	
	events	2	X	-		X		X			X	
	project	defaultWorkspaceManager 3			-		X				X	
		defaultworkspacecontext 4				-					X	
		partitioner 5					-			X	X	
		projectorLoader 6						-			X	
		projectView 7						X	-		X	
		projectUpdater 8								-	X	
		project 9	X	X	X	X	X	X	X	X	-	
	services	10						X				-

Component 9 (Project) is the change propagator

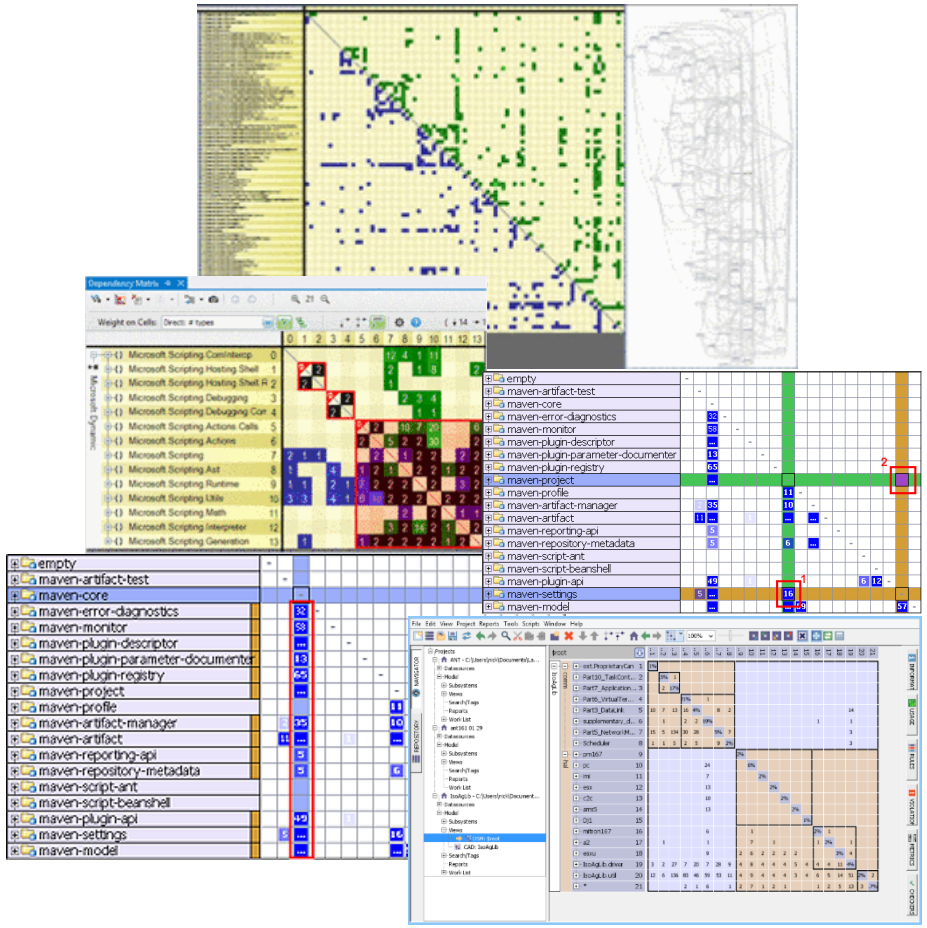
Imagine a change in component 10 (services)

["Using dependency models to manage complex software architecture." Sangal et al. (2005)]

Tool support for DSM

Plenty of tools and plugins for DSM analysis and visualization

- Eclipse
  - DSM-viewer
  - Eclipse-DSM-viewer
  - jDSM
- IntelliJ IDEA
  - DSM Analysis
- NDepend
  - Institute of Product Development - **TUM**
- Lattix dependency manager - lattix.com



[For more information - http://www.dsmweb.org/en/dsm-tools/commercial-tools.html]

Benefits of DSM

- The matrix representation scales better than box-and-line diagrams
- Graphs are more intuitive but when the numbers of nodes and edges grow, they becomes very complex
- Helps to better understand the information flows
- The partitioning algorithms provide an automatic mechanism for architectural discovery in a large code base
  - possibility to spot structural patterns at a glance
- Efficient cycle detection in DSM
- Integration of dependency rules
  - C1 can-use C2
  - C1 cannot-use C2

Challenges in DSM

- A DSM is only as good as the knowledge that goes into it.

- Unknown interdependencies can exist
  - one of the primary sources of uncertainty
  - can emerge unexpectedly

- DSM is less intuitive as compared to a graph

["Design rules: The power of modularity." Baldwin, C.Y. and Clark, K.B. (2000)]