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Making Architectures Future-Proof Using Scenarios

Pierre America
Philips Research, Eindhoven, The Netherlands

Problem: Evolution of Long-Living Architectures

Given:

- Successful system architectures enjoy a **long life** (often more than 10 years).
  Reason: Implementing a new architecture is very expensive.
- The **requirements** on the systems can **change** drastically.
- Therefore the architecture must **evolve** to meet them.

Examples:

Problem:

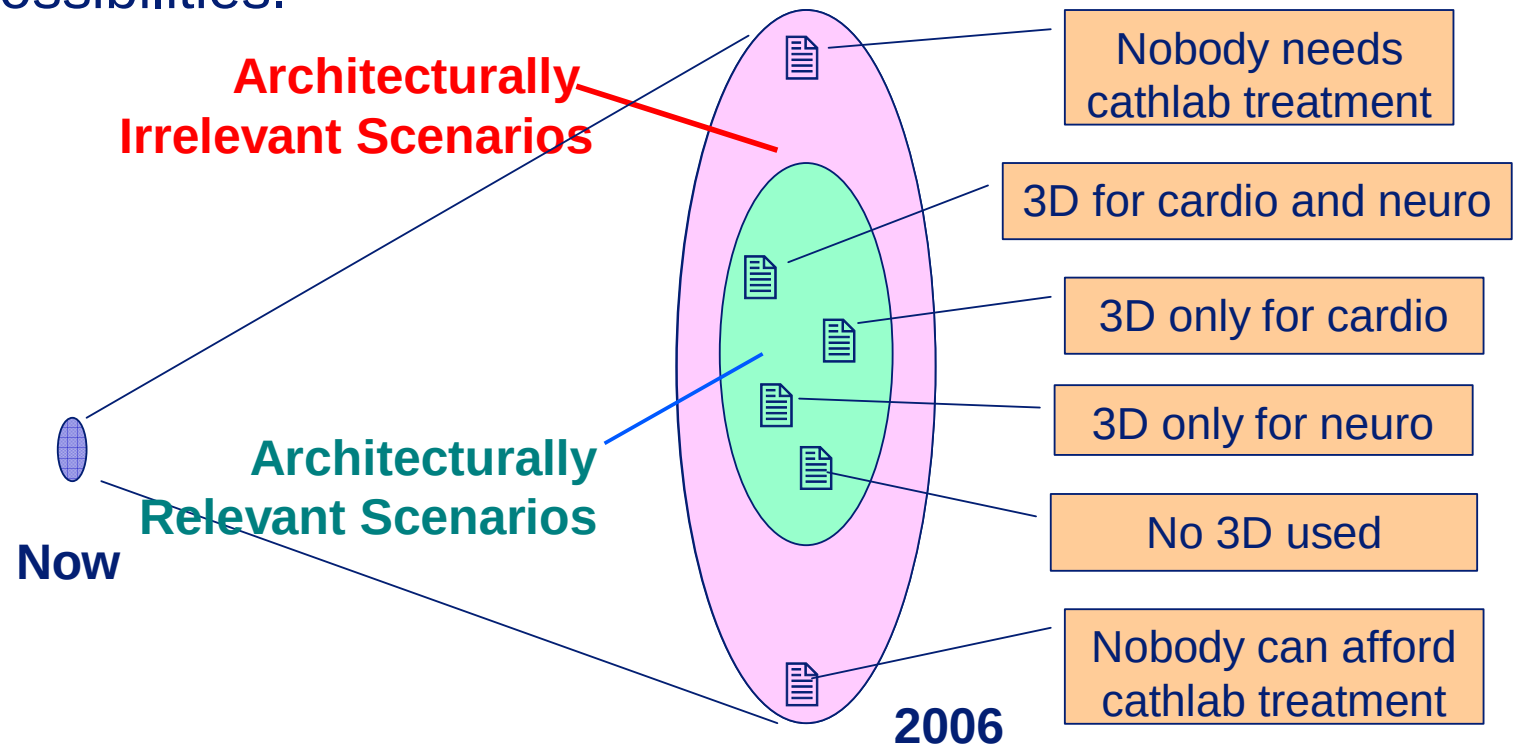
- How to **assess** and **improve** architecture evolvability?

Case Study: Cardiac Catheterization Lab

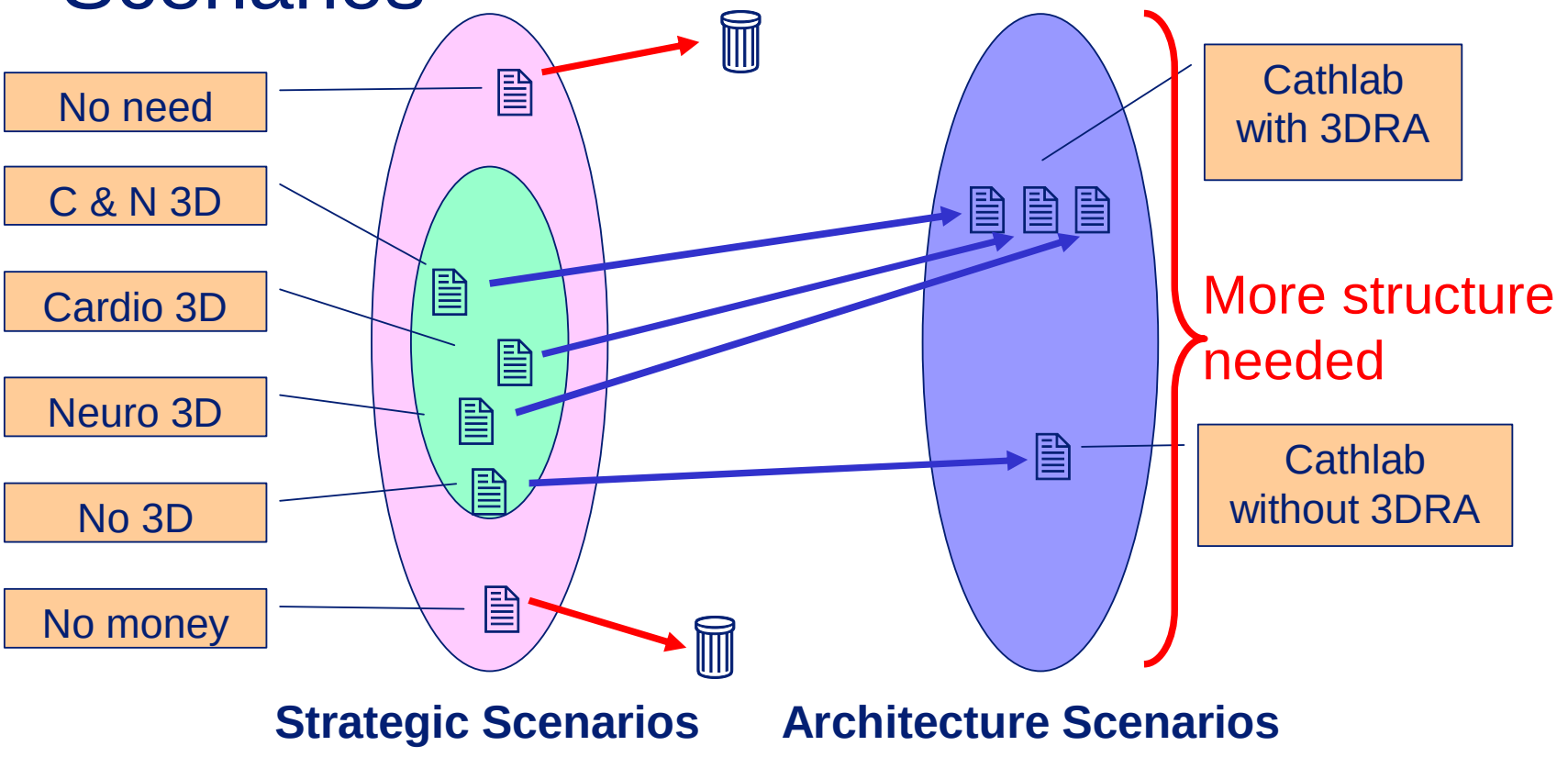
- In this cathlab, a patient with a stenosis (narrowing) in his artery is treated using a catheter inserted into a blood vessel.
- X-ray imaging makes the blood vessels and catheter visible.
- Philips Medical Systems is market leader for these cardiovascular X-ray systems.
- New technology: 3D Rotational Angiography (3DRA)

Strategic Scenarios

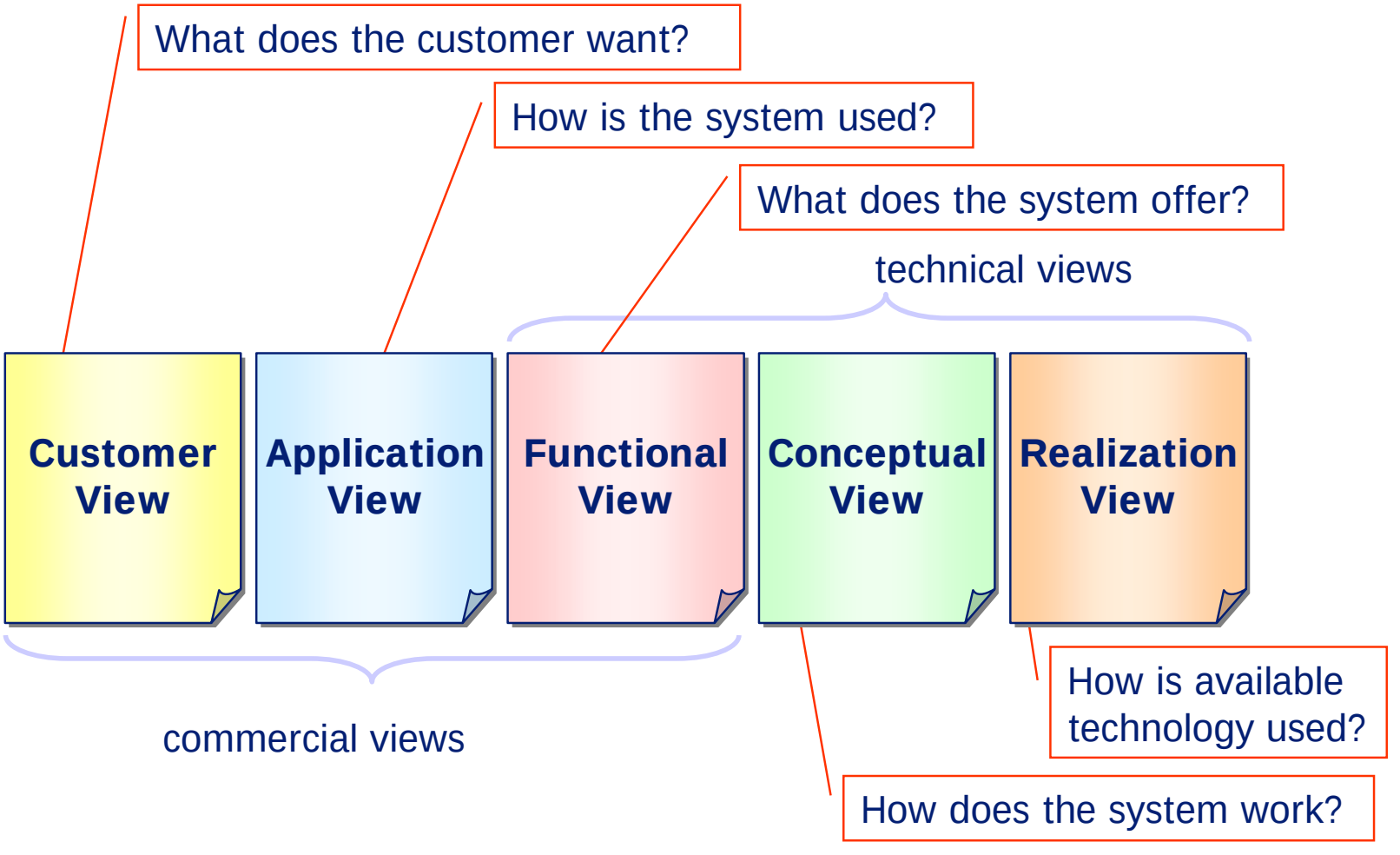
We don't know the future, so we consider several possibilities.



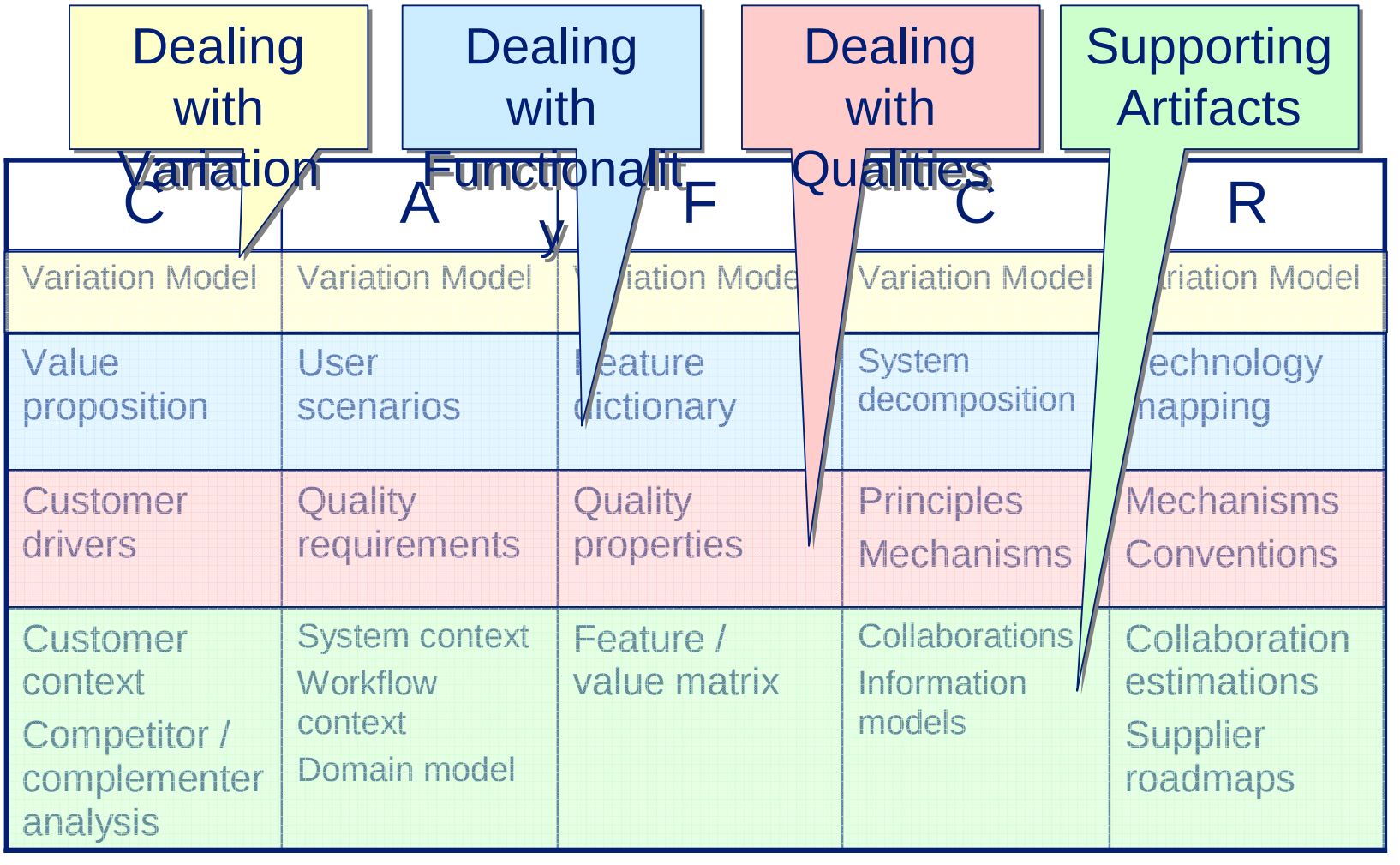
From Strategic to Architecture Scenarios



Architectural Views



Artifacts per View

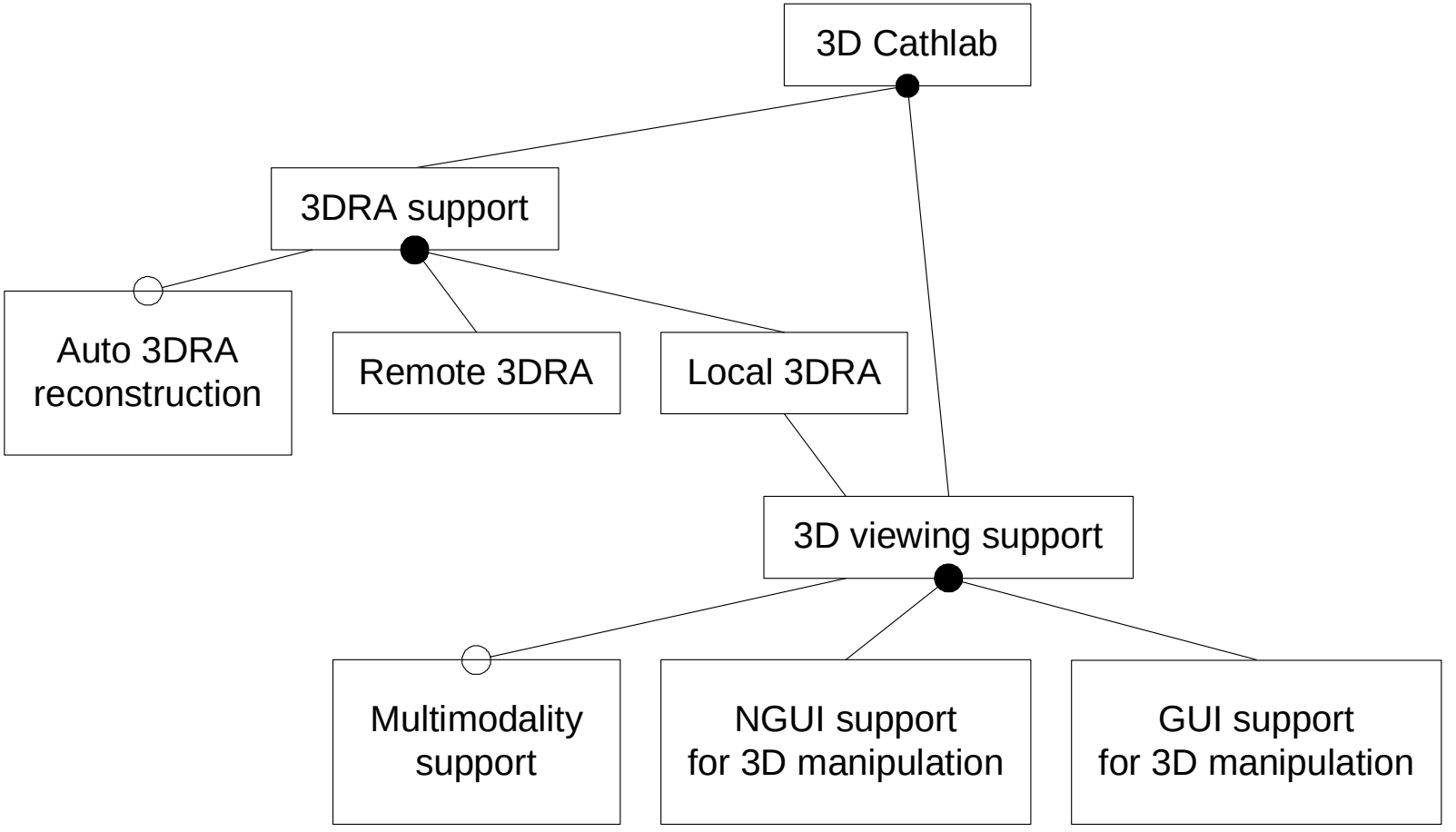


Variation Modeling

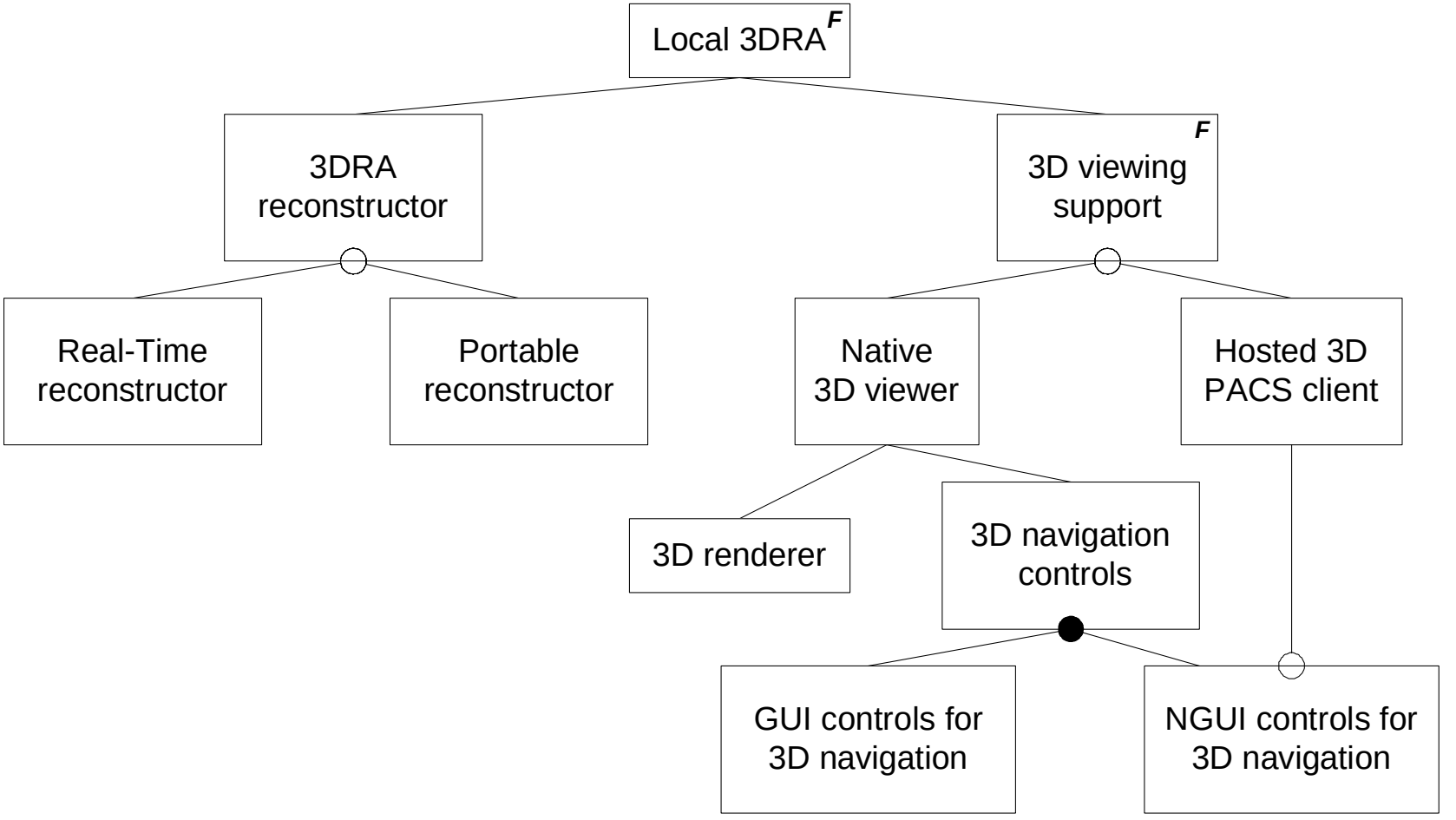
Goal: Overview of differences and commonalities among architectural scenarios

- Structurally explore the variation space in the various views, and relationships between them
- Guide and document choices that are made and options that are discarded
- Enhance communication and raise awareness about these choices among the architecture's stakeholders

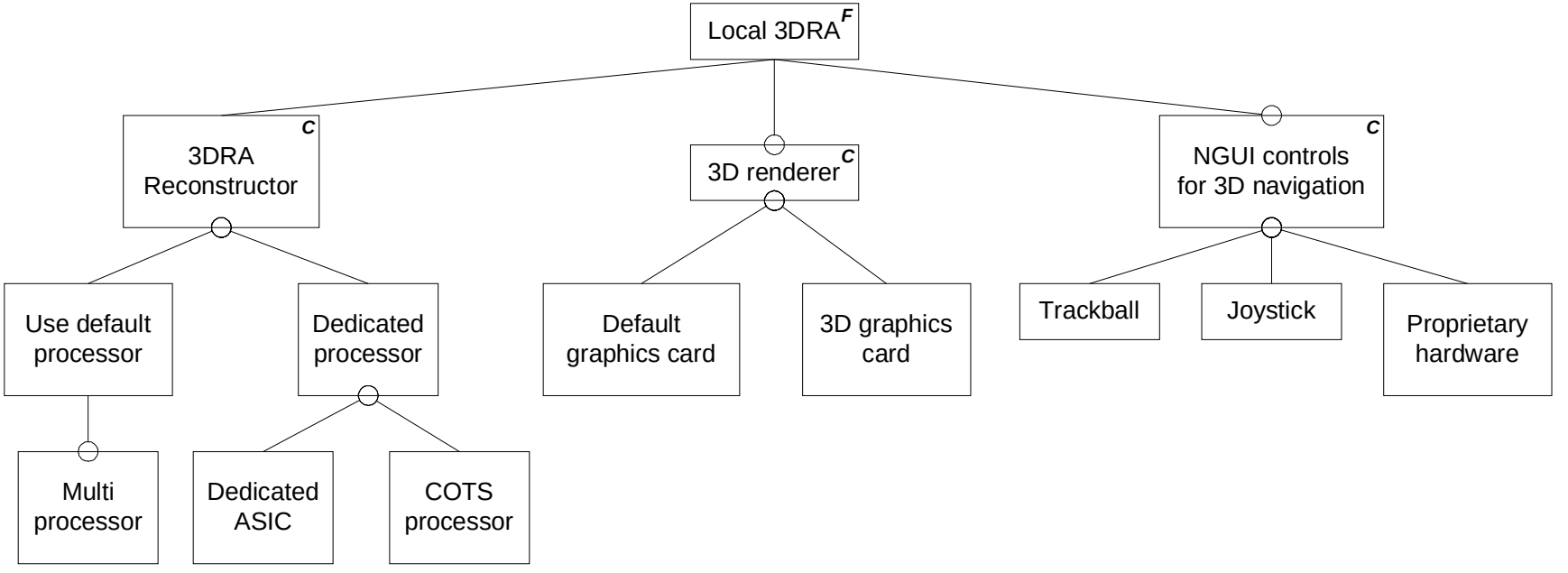
Functional Variation Model



Conceptual Variation Model

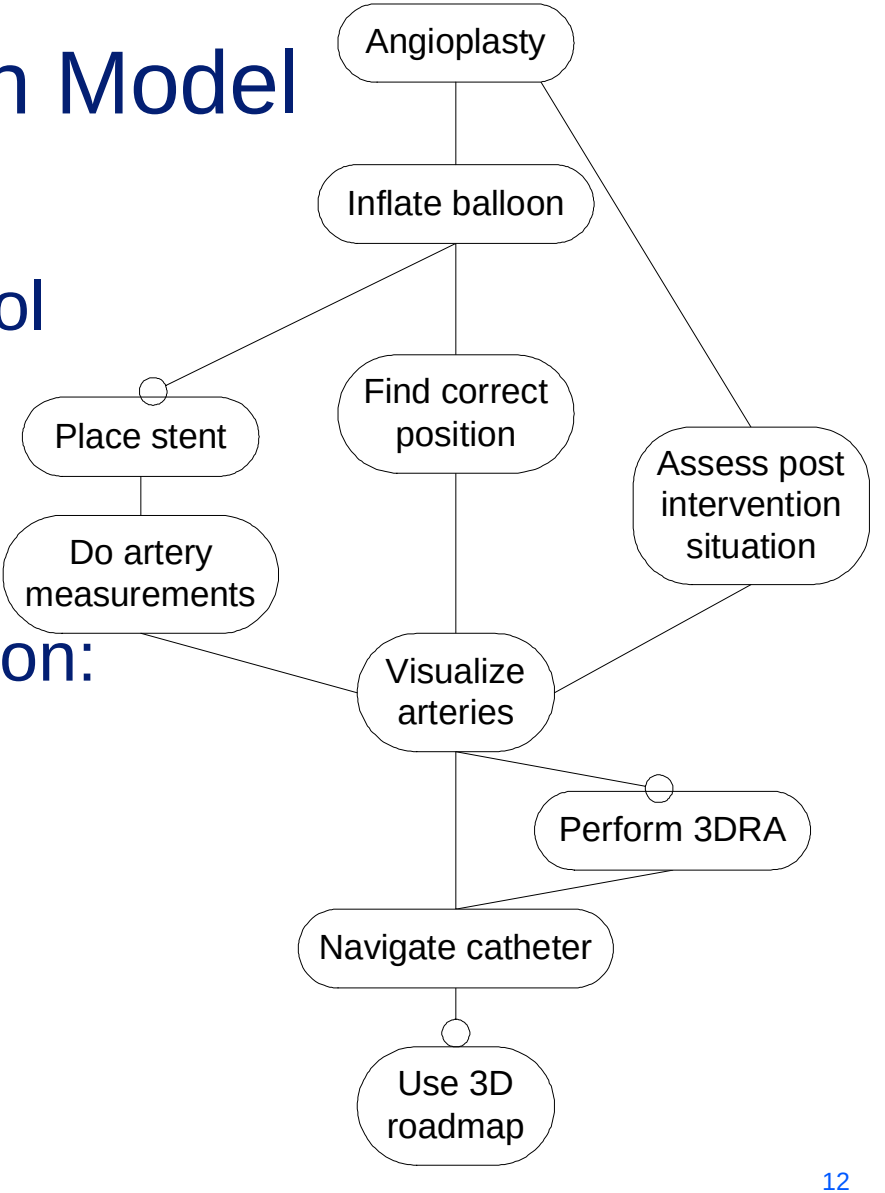


Realization Variation Model

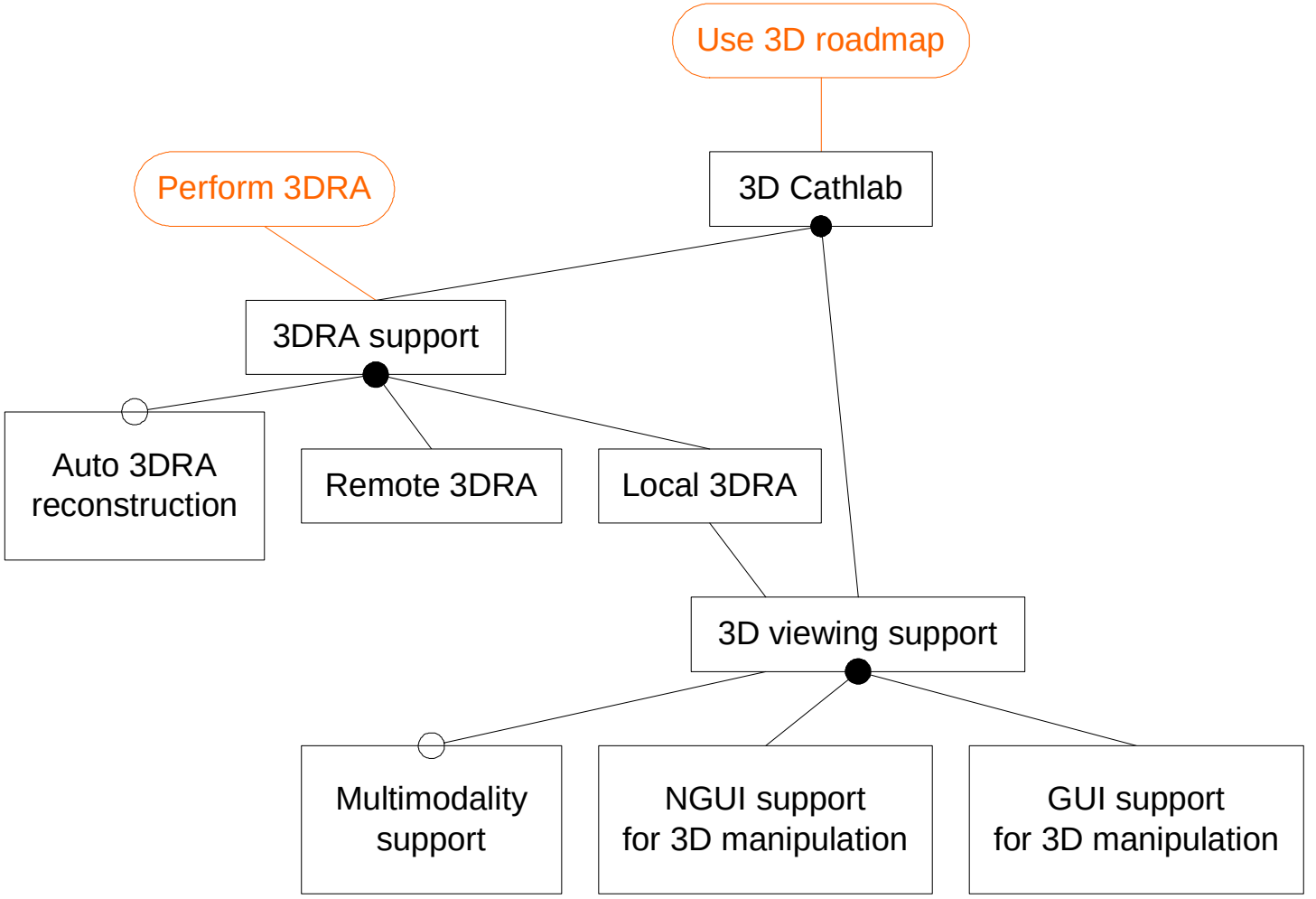


Application Variation Model

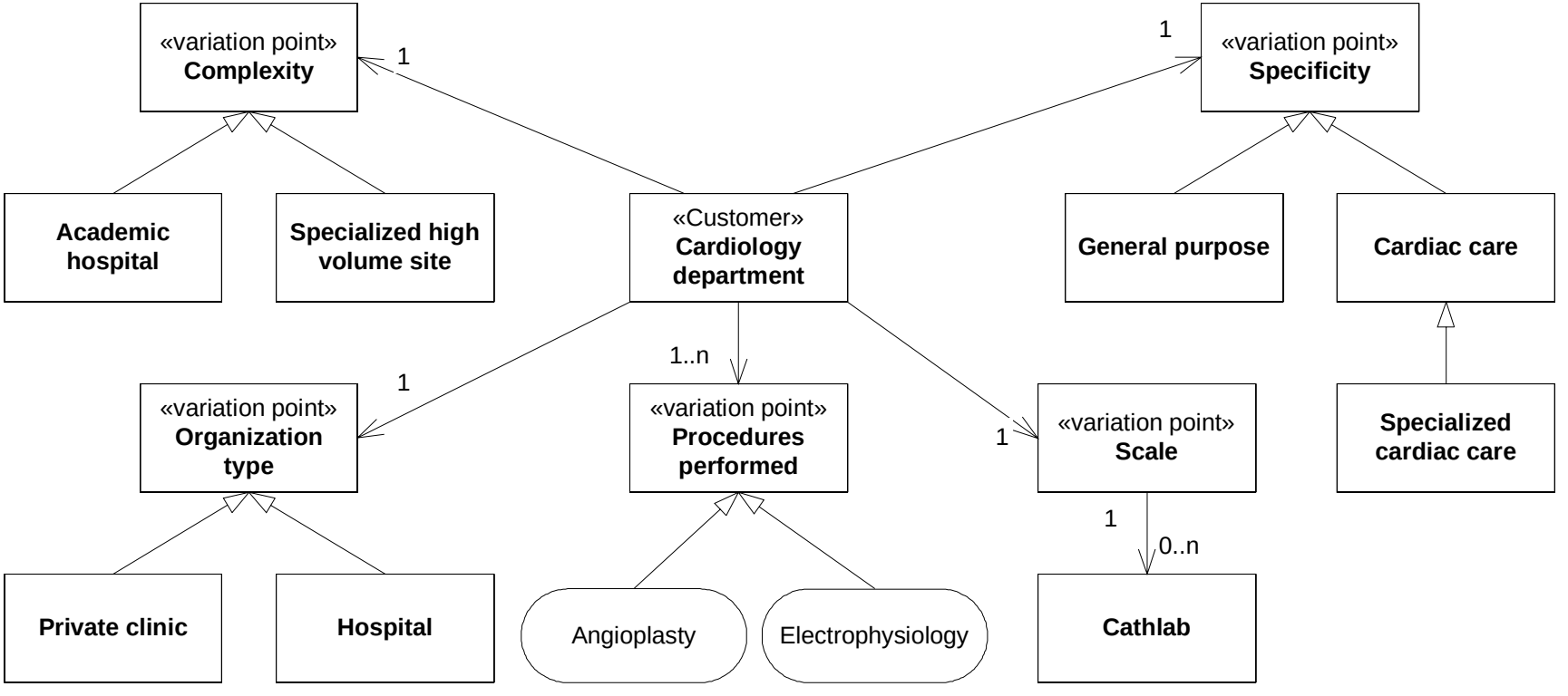
- Use UML activity symbol
- Not a workflow model (no temporal ordering of activities)
- Many sources of variation:
  - Architectural features
  - System context
  - Business goals
  - Personal preferences



Extended Functional Variation Model



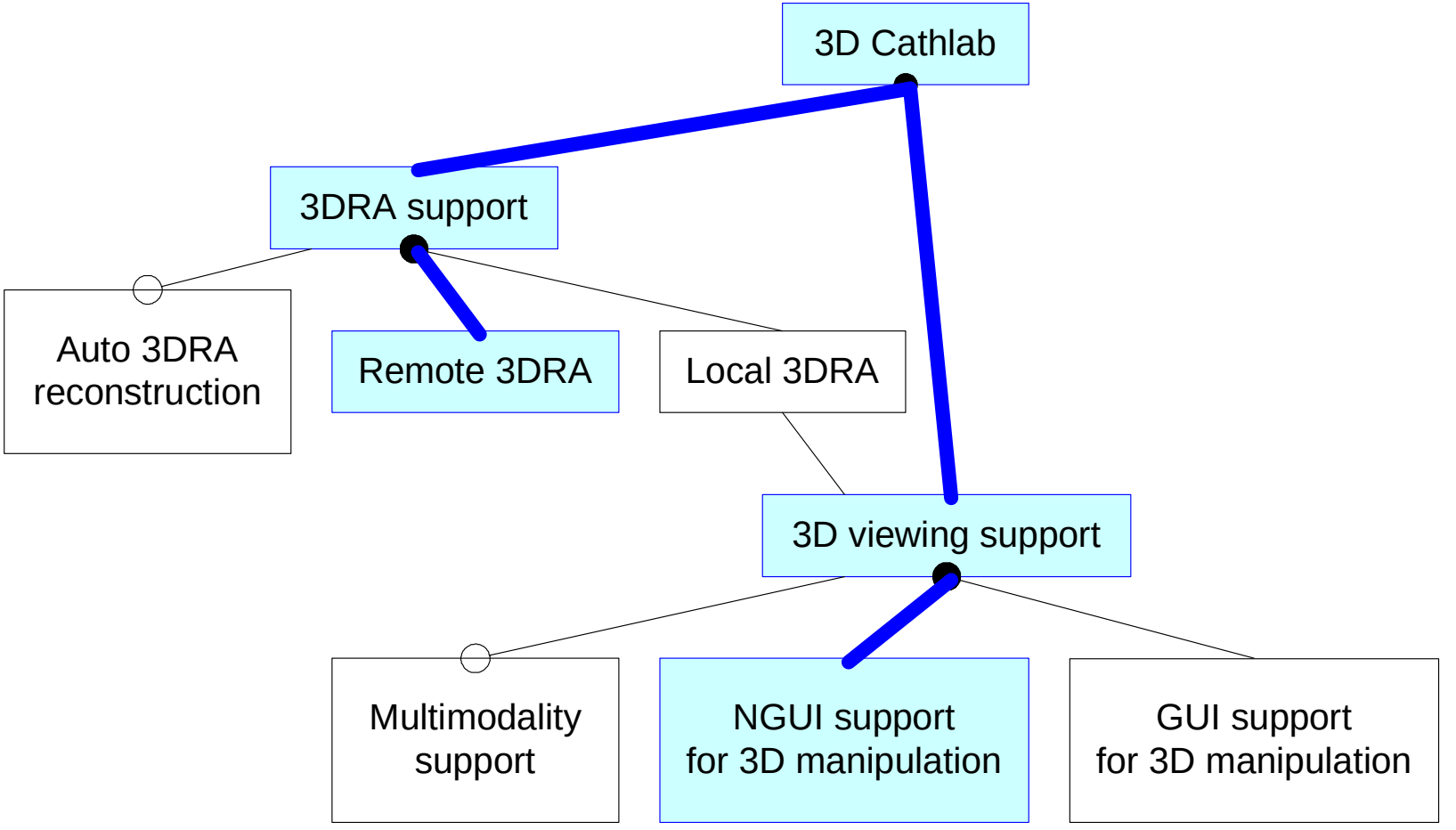
Customer Variation Model



Scenarios

- For each of the CAFCR views we can define a number of different *scenarios*.
- Each scenario consists of a consistent set of choices for the variation points.
- Of course the choices should preferably be reasonable and interesting
- The total number of scenarios should be limited, around 5 per view.

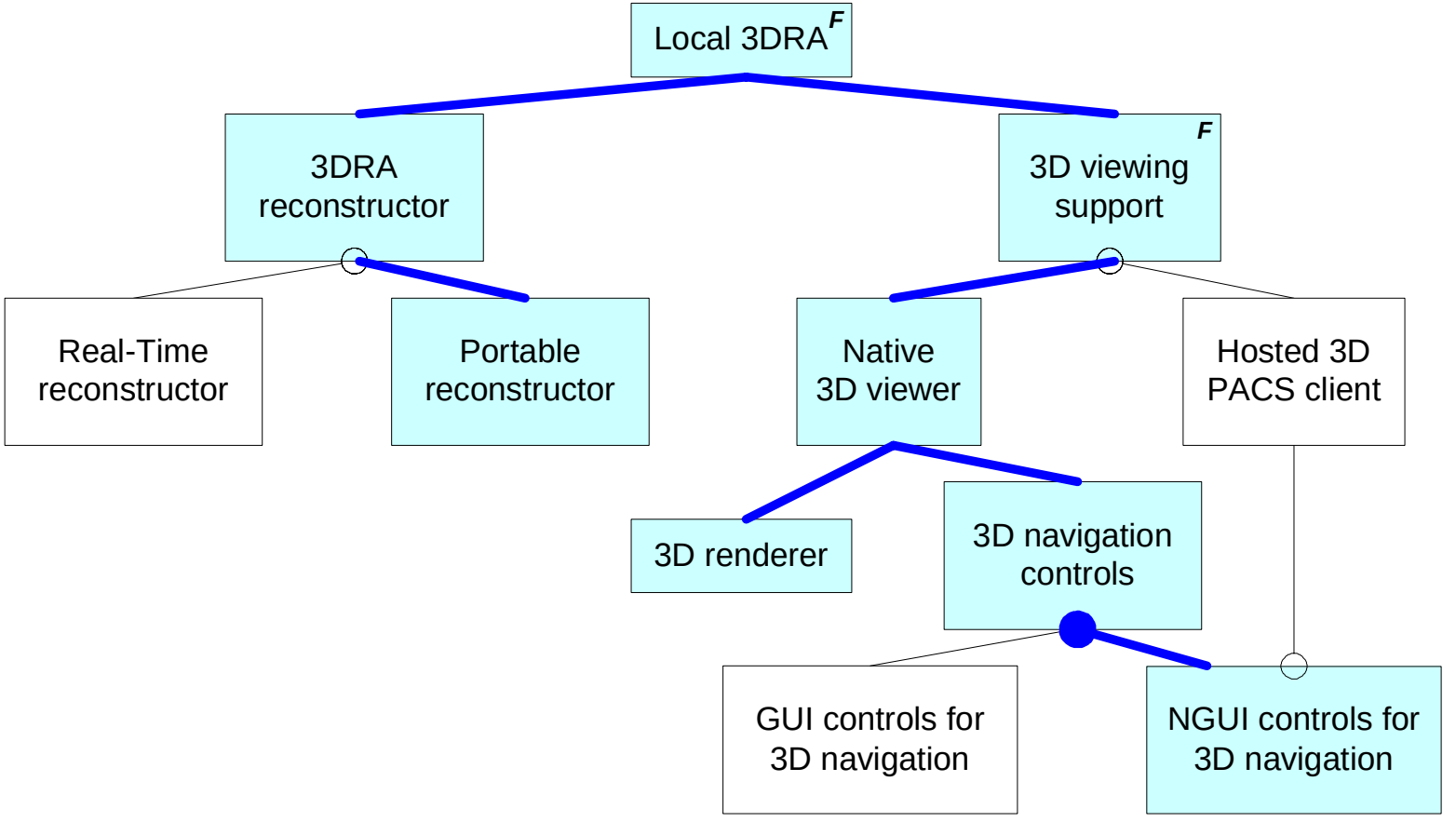
Example: Functional Scenario



Scenario Correspondence Across Views

- Two scenarios in different views are said to *correspond* to each other if their sets of choices match in terms of the overlap in the variation models

Example: Corresponding Conceptual Scenario



Scenarios Across Views

<table>
<tr><th>Customer</th><th>Application</th><th>Functional</th><th>Conceptual</th><th>Realization</th></tr>
<tr><td rowspan="3">Academic</td><td>Minimal</td><td>Minimal</td><td>-</td><td>-</td></tr>
<tr><td>Data</td><td>Data</td><td>DM Integr.</td><td rowspan="2">Multihost</td></tr>
<tr><td rowspan="3">Presentation & Control</td><td rowspan="3">Presentation & Control</td><td>HW switch</td></tr>
<tr><td rowspan="3">Production</td><td>Alt-Tab</td><td rowspan="2">Cohost</td></tr>
<tr><td>Workflow</td><td>Workflow</td><td>Coordinator</td></tr>
<tr><td>Full</td><td>Full</td><td>Luxury</td><td>TFT</td></tr>
</table>

Evaluating Quality Aspects

- Define a number of quality aspects; do this precisely and, if possible, quantitatively
- For each scenario, evaluate the quality aspects by any appropriate method
  - Expert judgement
  - Modeling
  - Simulation

Case Study: Usability in the Cathlab

Usability Objective	Usability Factor (Specific)	Metrics (Quantitative)
Efficiency	Personnel involved	Number of Cardiologists Number of Nurses Number of Technicians
	Number of atomic actions	Number of walks Number of sterilizations Number of buttons
Effectiveness	Error rate	Image quality Number of buttons
	Accuracy of the Intervention	Image quality
Satisfaction	Patient comfort	Intervention duration Physical support
	Invasiveness	X-ray Exposure Time Fluoroscopy Time Contrast agent amount

Usability Evaluation in Application View

	Minimal	Data	Presentation & Control	Workflow	Full
Cathlab description	✓				✓
Prepare MR study	✓	✓	✓		✓
Procedure logging	✓	✓	✓	✓	✓
Navigate catheter	✓				
Do exposure	✓				✓
Compare to MR study	✓	✓	✓		✓
Acquire 3DRA	✓		✓	✓	✓
View DRA	✓				✓
View 3DRA	✓		✓		
Do image analysis	✓	✓	✓		
Do hemo measurement	✓	✓	✓	✓	✓
Select stent	✓				
Place stent	✓				
Make/review exposure	✓				
Finalize	✓				

Red - Integration levels

Yellow - PACS integration

Blue - 3DRA integration

Green - Hemo integration

Usability Values per Scene

	Scene 1	Scene 2	Scene 3	Scene 4	Scene 5	Scene 6	Scene 7	Scene 8	Scene 9	Scene 10	Scene 11	Scene 12	Scene 13	Scene 14	Scene 15
walks	1	0	0	0	0	1	0	0	1	1	0	0	0	0	0
resteri	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
pers	0	1	1	1	1	2	1	1	3	3	2	1	1	1	2
fluo	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0
angio	0	0	0	0	400s	0	200s	0	0	0	0	0	0	200s	0
exprep	0	0	0	0	2220s	0	1020s	0	0	0	0	0	0	1120s	0
exdur	0	0	0	0	12s	0	6s	0	0	0	0	0	0	6s	0
expos	0	0	0	0	2	0	1	0	0	0	0	0	0	1	0

Aggregated Usability Results

	Minimal	Data	Presentation & Control	Workflow	Full
Number of walks	4	3	0	0	0
Number of re-sterilizations	0	0	0	0	0
Personnel Involved	3	3	2	2	2
Number of Fuloroscopies	2	2	2	2	2
Angiography	800 s	800 s	800 s	800 s	202 s
Exposure Preparation	4300 s	4300 s	4300 s	4300 s	2100 s
Exposure Duration	24 s	24 s	24 s	24 s	18 s
Number of Exposures	4	4	4	4	3

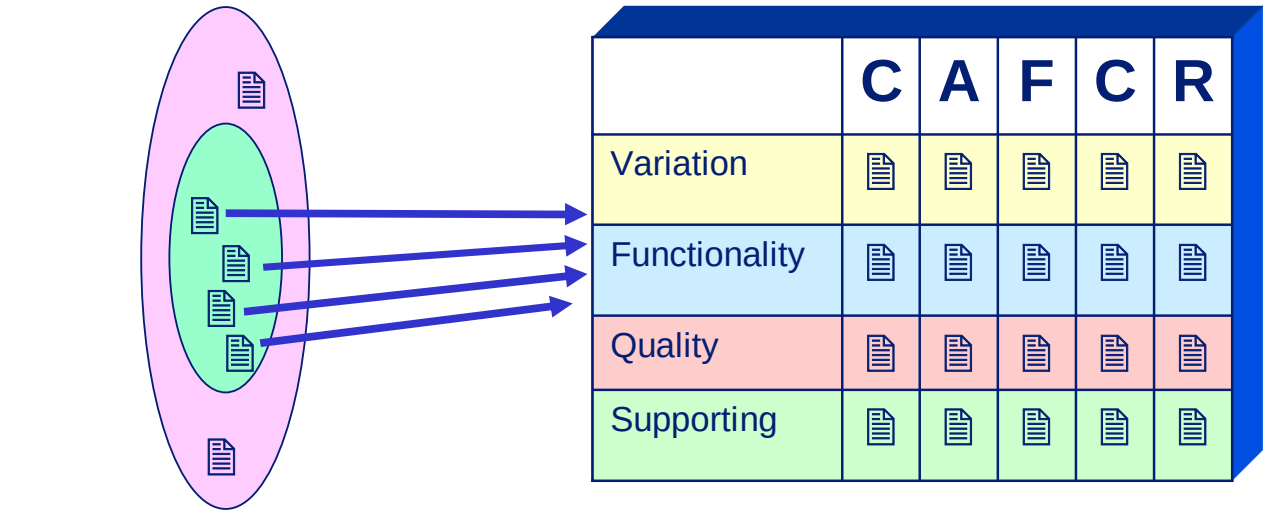
Determining and Assessment Views

- **Determining view:**
  The view where the architectural *decisions* are made that determine the quality of the system.
- **Assessment view:**
  The view where the *resulting* system qualities can be assessed.

Examples of Determining and Assessment Views

Quality aspect	Determining view	Assessment view
Usability	Functional	Application
Performance	Conceptual, Realization	Application
Salability	Functional	Functional, Customer
Development cost	Conceptual	Conceptual, Realization
Usage hazards	Conceptual, Realization	Application
Development risk	Conceptual	Conceptual

Method Overview



Strategic Scenarios

Integral Architecture

Conclusions

Method ingredients:

- Cross-view variation modeling
- Architectural scenarios per view
- Quantitative analysis of quality aspects

This approach helps improve future-proofness beyond roadmapping

It requires a mature organization, where roadmapping is already well established.