14. The Tools And Materials Architectural Style and Pattern Language (TAM)

Prof. Dr. U. Aßmann
Chair for Software Engineering
Faculty of Informatics
Dresden University of Technology
13-0.1, 12/28/13

This pattern language is one basic strand in the course "Metamodelling and Software Tools" (Winter Term). Welcome!

Literature

- D. Riehle, H. Züllighoven. A Pattern Language for Tool Construction and Integration Based on the Tools&Materials Metaphor. PLOP I, 1995, Addison-Wesley.
- JWAM: Still available on Sourceforge http://sourceforge.net/projects/jwamtoolconstr/
  - A copy of jwam.org is in the Internet Archive, also literature
  - http://web.archive.org/web/20041009212341/www.jwam.org/engl/produkt/e_literature.htm
  - Thanks to Moritz Bartl!

Literature

- D. Riehle, H. Züllighoven. A Pattern Language for Tool Construction and Integration Based on the Tools&Materials Metaphor. PLOP I, 1995, Addison-Wesley.
- JWAM: Still available on Sourceforge http://sourceforge.net/projects/jwamtoolconstr/
  - A copy of jwam.org is in the Internet Archive, also literature
  - http://web.archive.org/web/20041009212341/www.jwam.org/engl/produkt/e_literature.htm
  - Thanks to Moritz Bartl!

Secondary Literature

- Heinz Züllighoven et.al. The object-oriented construction handbook. Morgan Kaufmann Publishers, 2004. The TAM explained in detail.
- In German: Heinz Züllighoven et.al. Das objektorientierte Konstruktionshandbuch – nach dem Werkzeug und Material-Ansatz. Dpunkt-Verlag, Heidelberg, 1998.
- D. Riehle. Framework Design – A Role Modeling Approach. PhD thesis 13509, ETH Zürich, 2000. Available at http://www.riehle.org.

Exam Questions (Examples)

- What are the central metaphors of the Tools-and-Materials architectural style?
- Explain tool-material collaboration. Which roles do role models play?
- How are tools structured?
- How is TAM arranged as a layered framework?

Why Do People Prefer to Use Certain Software Systems?

- People should feel that they are competent to do certain tasks
- No fixed workflow, but flexible arrangements with tools
  - Domain office software, interactive software
- People should decide on how to organize their work and environment
- People want to work incrementally, in piecemeal growth

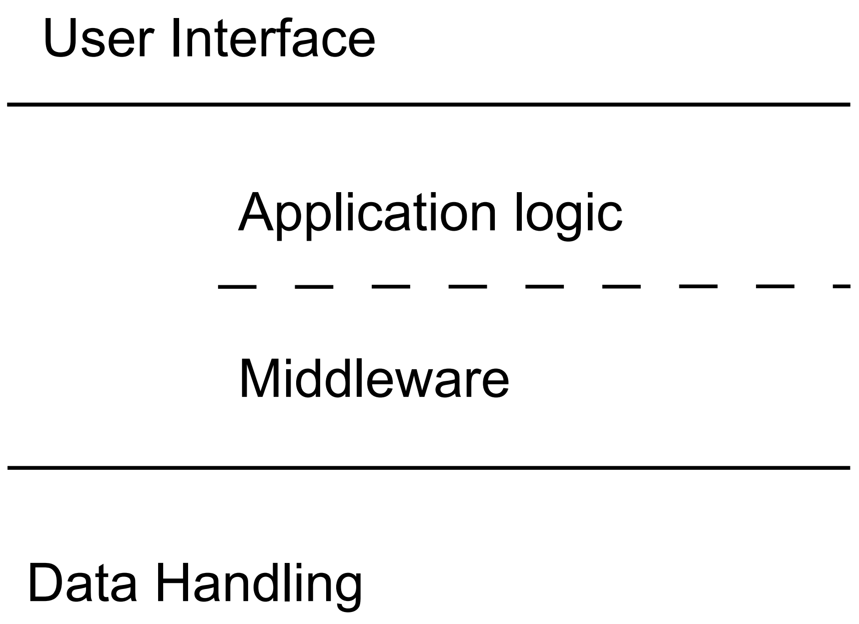
14.1 Elements of “Tools and Materials“

The Central T&M Metaphor

- Tools and Materials pattern language T&M
  - Werkzeug und Material (WAM)
  - Craftsmanship: Craftsmen use tools to work on material
- People use tools in their everyday work: Tools are means of work
  - People use tools to work on material
- T&M-collaboration: Tools and materials are in relation
- Environment: Craftsmen work in an environment

And 3-Tier Architectures?

- Another popular architectural style for interactive applications is 3-tier architecture
- However, the 3-tiers are so coarse-grained that they do not really help for interactive applications
- T&M is much more detailed



Material

- Passive entities, either values or objects
  - Ex.: Forms laid out on a desktop, entries in a database, items in a worklist
- Prepared and offered for the work to be done
- Transformed and modified during the work
- Not directly accessible, only via tools

- Values (e.g., Dates, Money)
  - Without time and position
  - Abstract, without identity
  - Equality is on value
  - A value is defined or undefined, but immutable
  - Cannot be used in a shared way
  - Structured (then every subvalue has 1 reference), such as documents
  - are domain-specific, such as business values (value objects with value semantics)

- Objects (e.g., Persons, technical objects, Bills, Orders)
  - With time and position
  - Concrete, with identity
  - Equality is on *names*
  - Mutable; identity does not change
  - Shared by references
  - Structured (a subvalue may have several references)

Tools

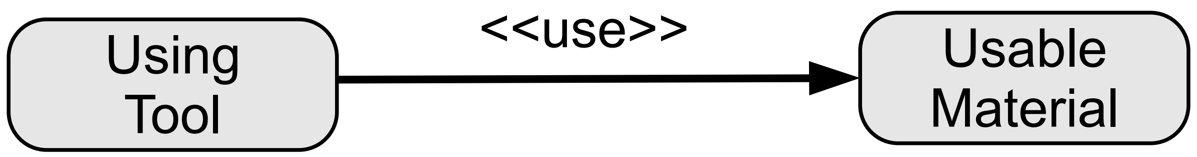
- Active entitites
  - Tools are means of work. They embody the experience of how to efficiently work with material
  - Present a view on the material.
  - Often visible on the desktop as wizards, active forms,..
  - Tools give feedback to the user
  - Tools have a state
- If well-designed, they are transparent, light-weight, and orthogonal
  - However, they should not disappear, since users need to look at a tool if they are worried
- Examples:
  - Browser – Contents of a folder
  - Interpreter – Code and data
  - Calendar - Calendar data
  - Form editor - Form

Tools vs. Material

- To say, what is a tool and what the material, depends a lot on the concrete task (interpretation freedom)
  - Pencil -– paper
  - Pencil sharpener - pencil
- Tools can be structured
  - Supertools and subtools, according to tasks and subtasks
  - e.g., Calendar = AppointmentLister + AppointmentEditor
- In implementations, tools are a often realized as a variant of the Command/Objectifier reified actions
  - They have a function execute()

Tools and Materials as Special Role Model

- The tool is active, has control
- The material is passive and hands out data
  - We work with different tools on the same material

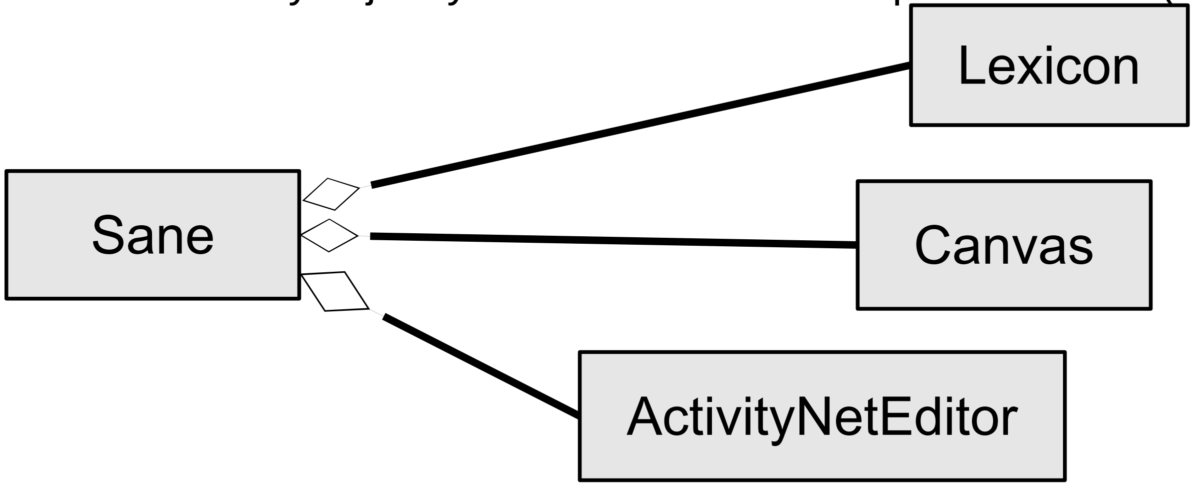


(Work-)Environment

- The (Work-)Environment to organize the tools, materials, and T&M-collaborations
  - Tools can be created from the environment by tool factories (Factory pattern)
  - Materials can be created from the environment by material factories
  - Corresponds to the metaphors of a workshop or desktop
- Environment for planning, working, arranging, space
  - Several logical dimensions to arrange things

Running Example: TORA Tools

- Requirements Analysis Tool for Task-oriented Requirements Analysis (TORA)
- Editor SANE for activity nets in requirements analysis. subtools:
  - **Glossary browser** Lexicon to manage glossaries about requirement specifications
  - **Canvas** for the editor's graphical objects. Manipulates the editor's visible materials (Graphical objects, GraphObj):
    - Edit shapes, icons, representation
    - Annotate activity nets
  - **ActivityNetEditor** for logical materials ActivityObj
    - An ActivityObj may have several visual representations (GraphObj)

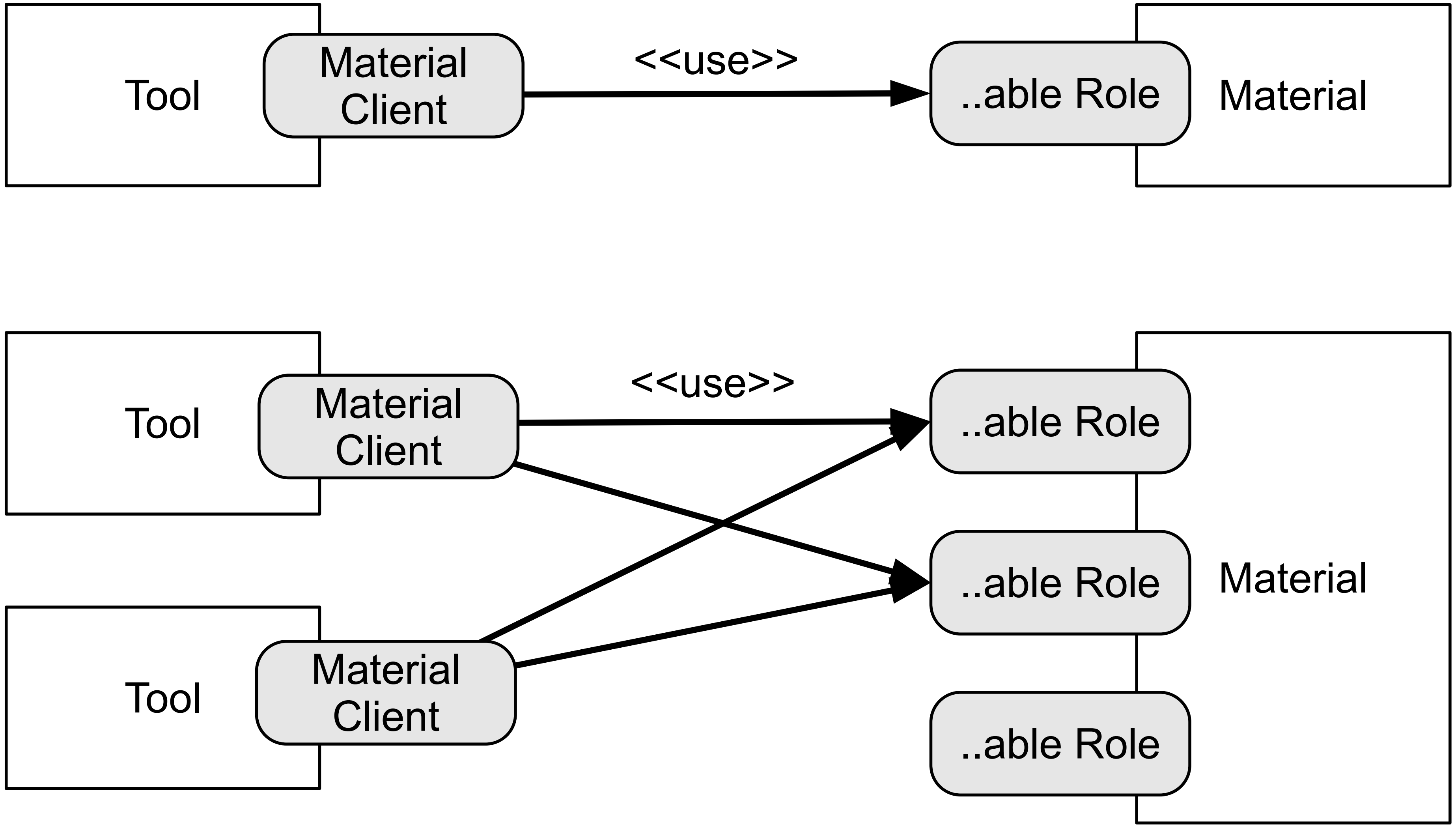


14.2 Tool Construction

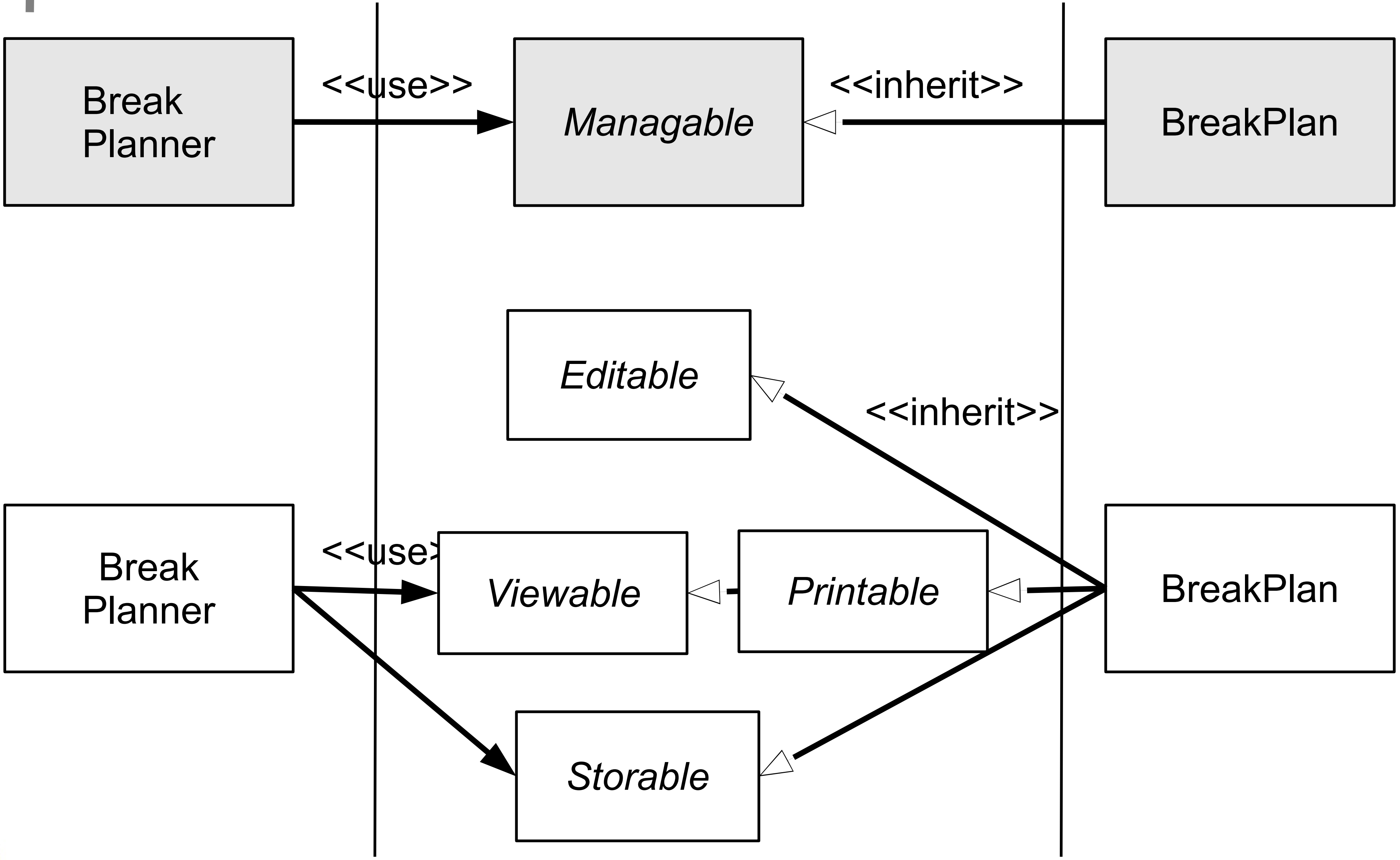
Tool-Material Collaboration Pattern

- A *tool-material collaboration (*T&M role model, T&M access aspect) expresses the relation of a tool and the material
  - Characterizes a tool in the context of the material
  - The material in the context of a tool
  - The tool's access of the material. The tool has a view on the material, several tools have different views
- More specifically:
  - A *role* of the material, in collaboration with a tool
    - An interface of the material, visible by a tool, for a specific task
    - An abstract class
  - Roles of a material define the necessary operations on a material for one specific task
    - They reflect usability: how can a material be used?
    - Express a tool's individual needs on a material

Tools and Their Views on Material



Tools/Views/Material with ..able-Interfaces

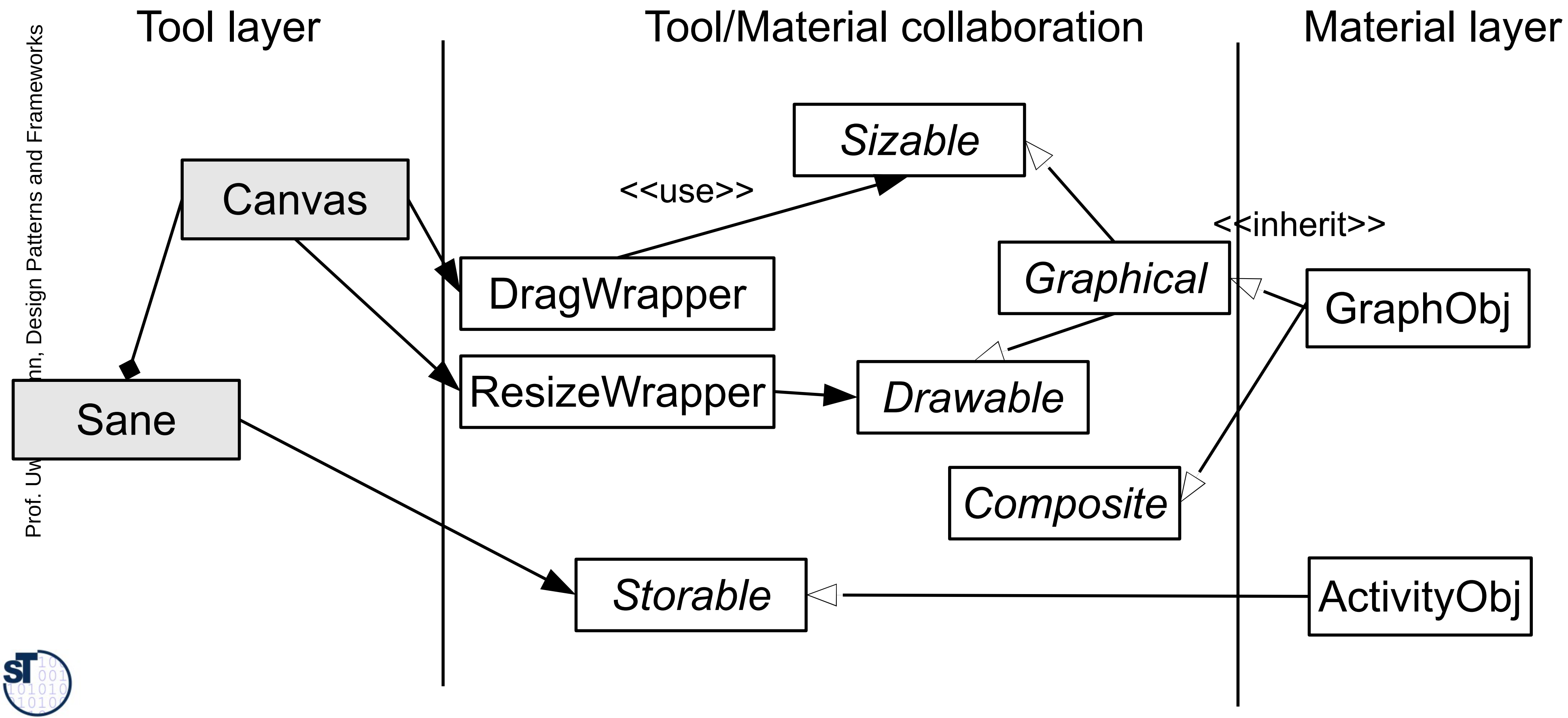


Names of Roles

- The notion of a material-role helps a lot to understand the functionality of the materials
  - And helps to separate of them
- Often a “adjectified verb”, such as Listable, Editable, Browsable, expresses the ability of a material from the perspective of a tool

Ex.: Access To Materials In TORA

- Access from tools to material via material-roles
  - Main tool Sane: Storable
  - Tool Canvas: Drawable, Sizable with the help of wrappers DragWrapper, ResizeWrapper

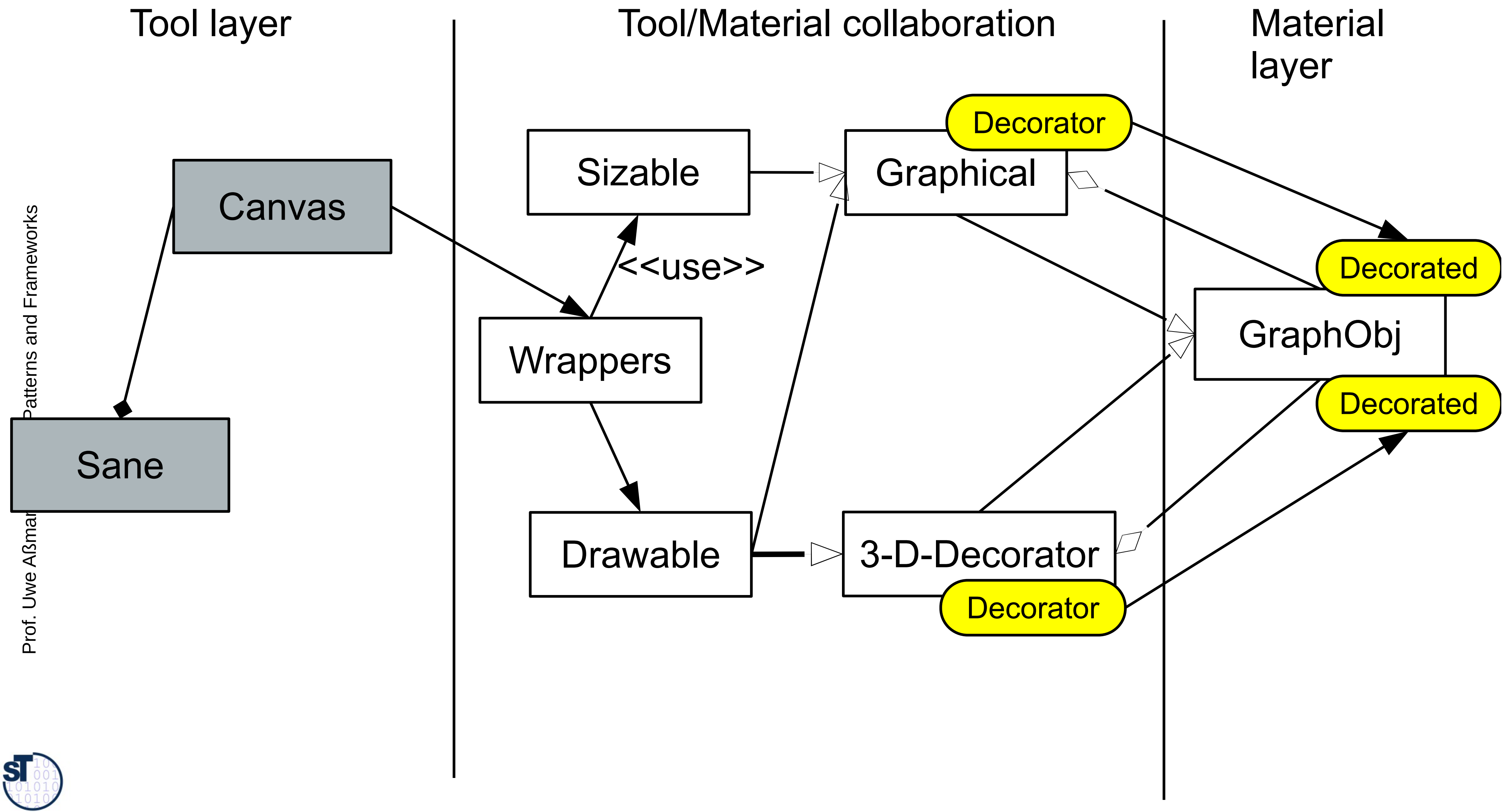


Alternative Implementations of Tool-Material Collaboration

- See chapter on role implementation
  - Construction of roles by interfaces
  - By multiple or mixin inheritance
- By ObjectAdapter pattern
- By Decorator pattern
- By Role-Object Pattern
- By GenVoca Pattern

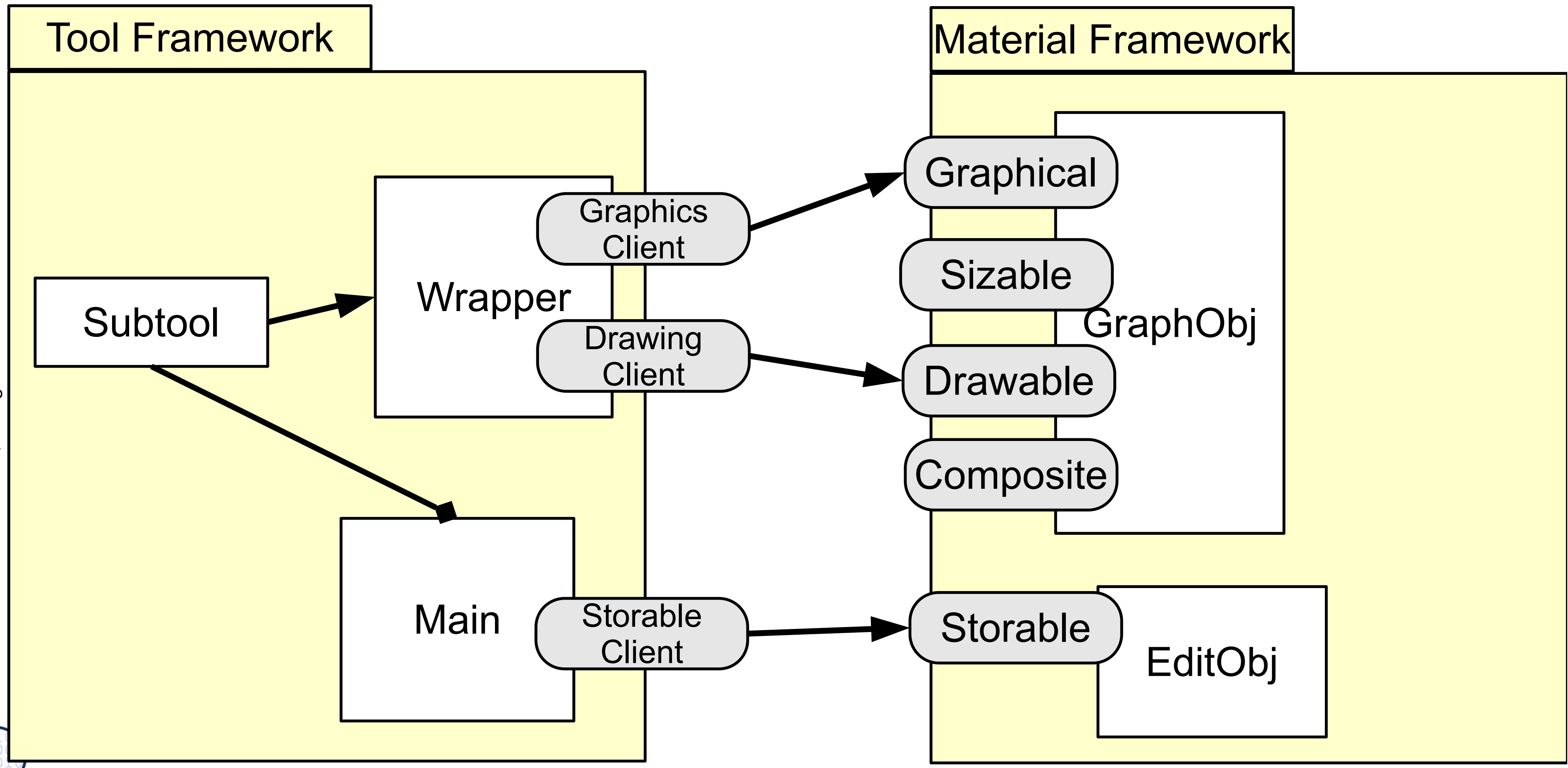
Ex.: Tools Accessing Material Via Decorators

- Converting roles into decorator objects



Composition of a Tool and a Material Framework With Collaboration Roles

- Since Material-roles are roles, Tool layer and Material layer can be modeled as frameworks (which then can be composed by role composition/use)

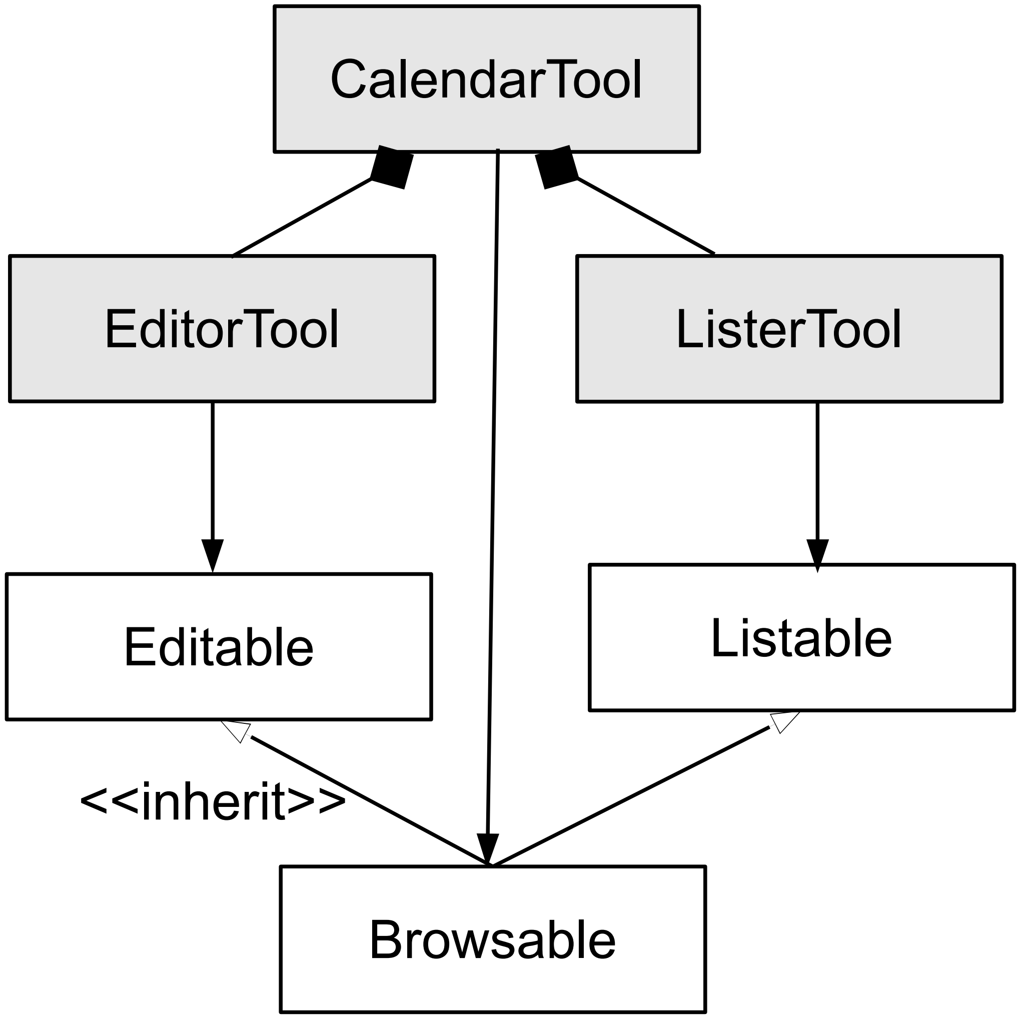


Tool Construction: Structured Tool Pattern

- Structured tools
  - Atomic tools
  - Composed tools (with subtools)
  - Recursively composed tools (Composite pattern)
- Structured along the tasks
- A complex tool creates, delegates to, and coordinates its subtools

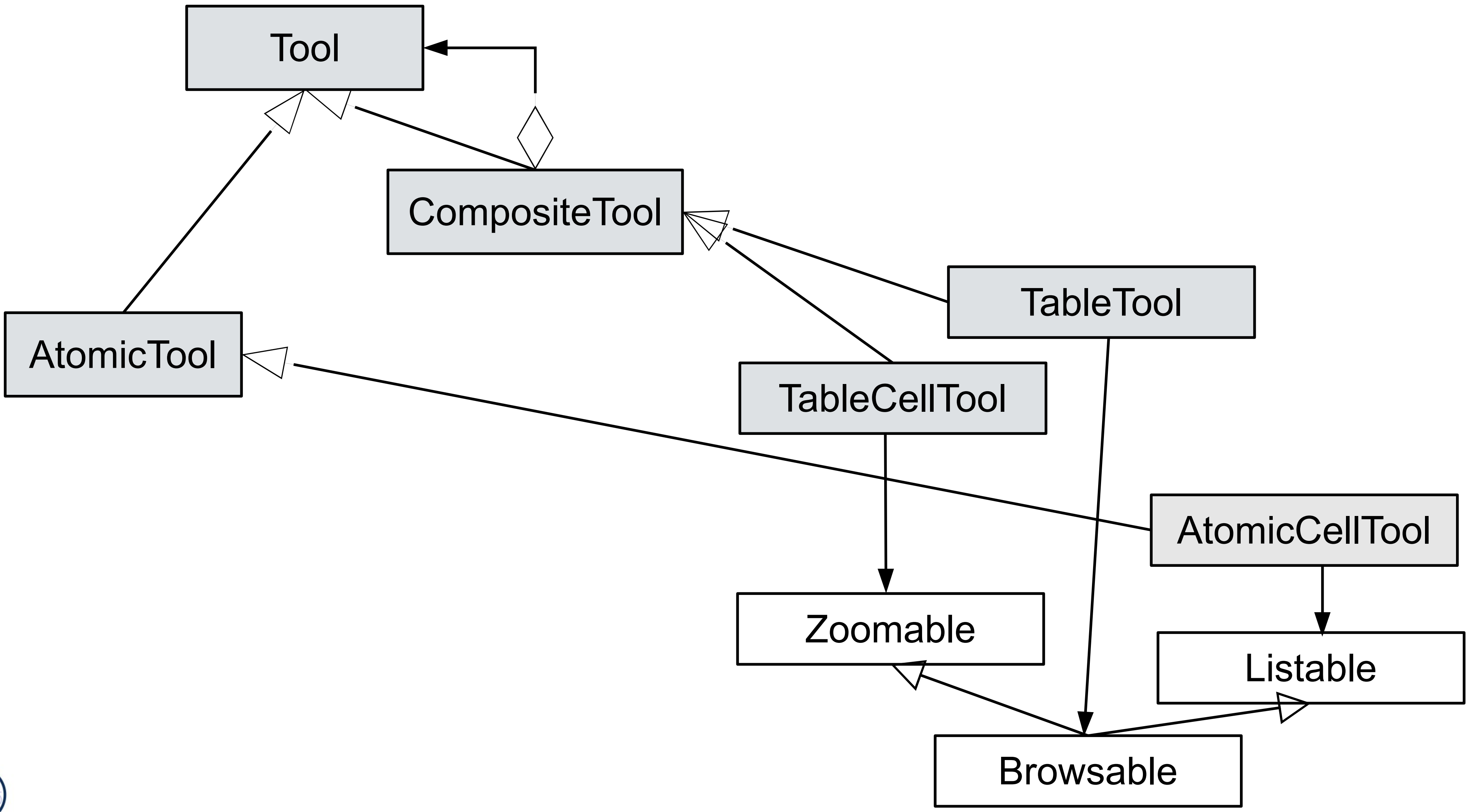
Tool Construction: Structured Tool Pattern

- Subtools are aggregated
- A subtool can work on its own material
  - Or on the same material as a supertool, but with fewer or less complex roles
- Advantage: complex tools see complex roles, simple tools simple roles
- The role hierarchy opens features of the material only as needed (good information hiding)



Tool Construction: Composite as Structured Tool Pattern

- The Composite pattern can be used to build up recursive tools

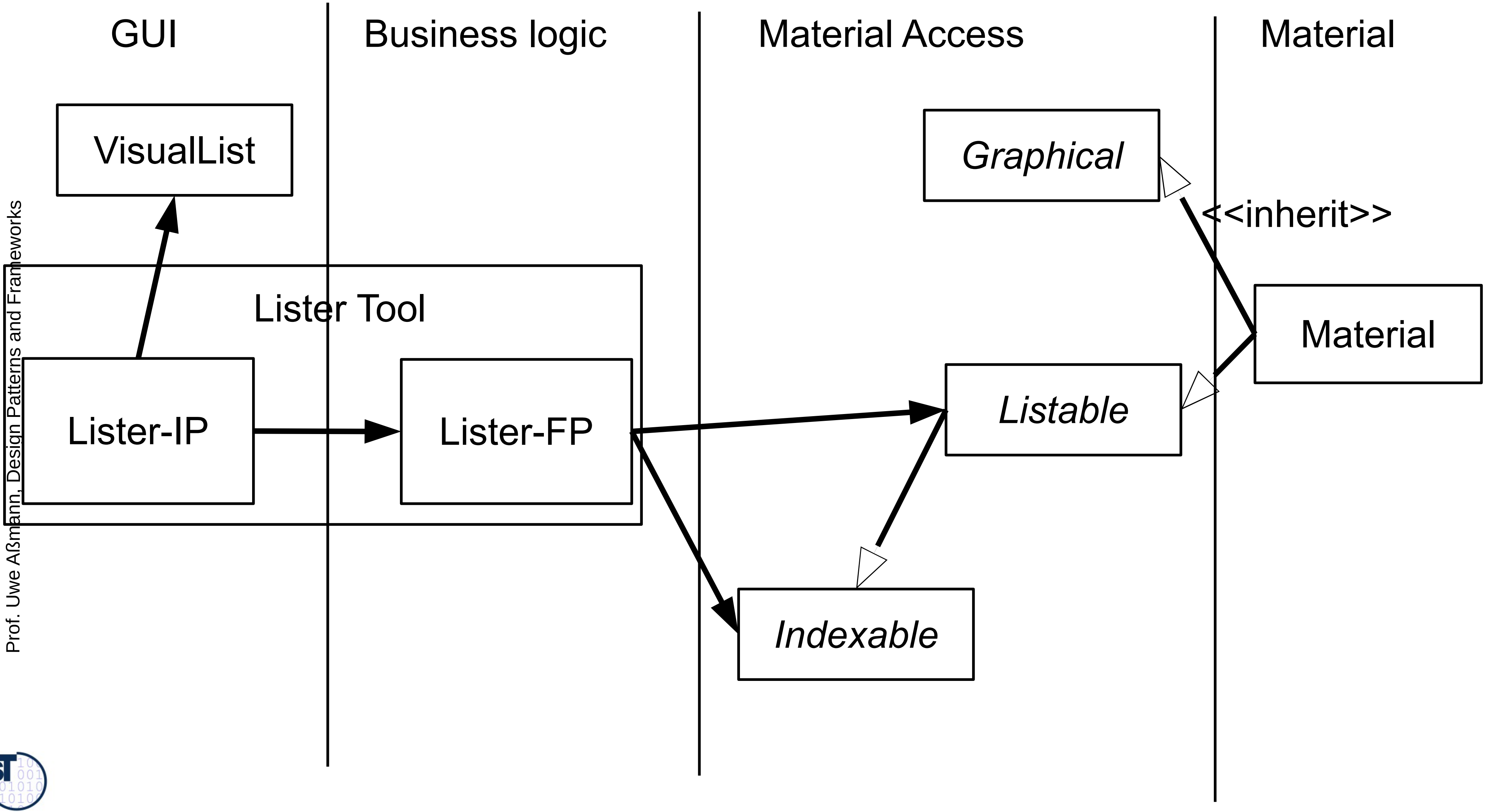


Tool Construction: Separation of Function and Interaction

- Separation of function and interaction
  - Separation of user interface and application logic, as in 3-tier
  - Tools have one functional part and one or several interaction part
- Functional Part (FP):
  - Manipulation of the material
  - Access to Material via material-roles
- Interaction Part (IP):
  - Reactive on user inputs
  - Modeless, if possible
  - Can be replaced without affecting the functional part

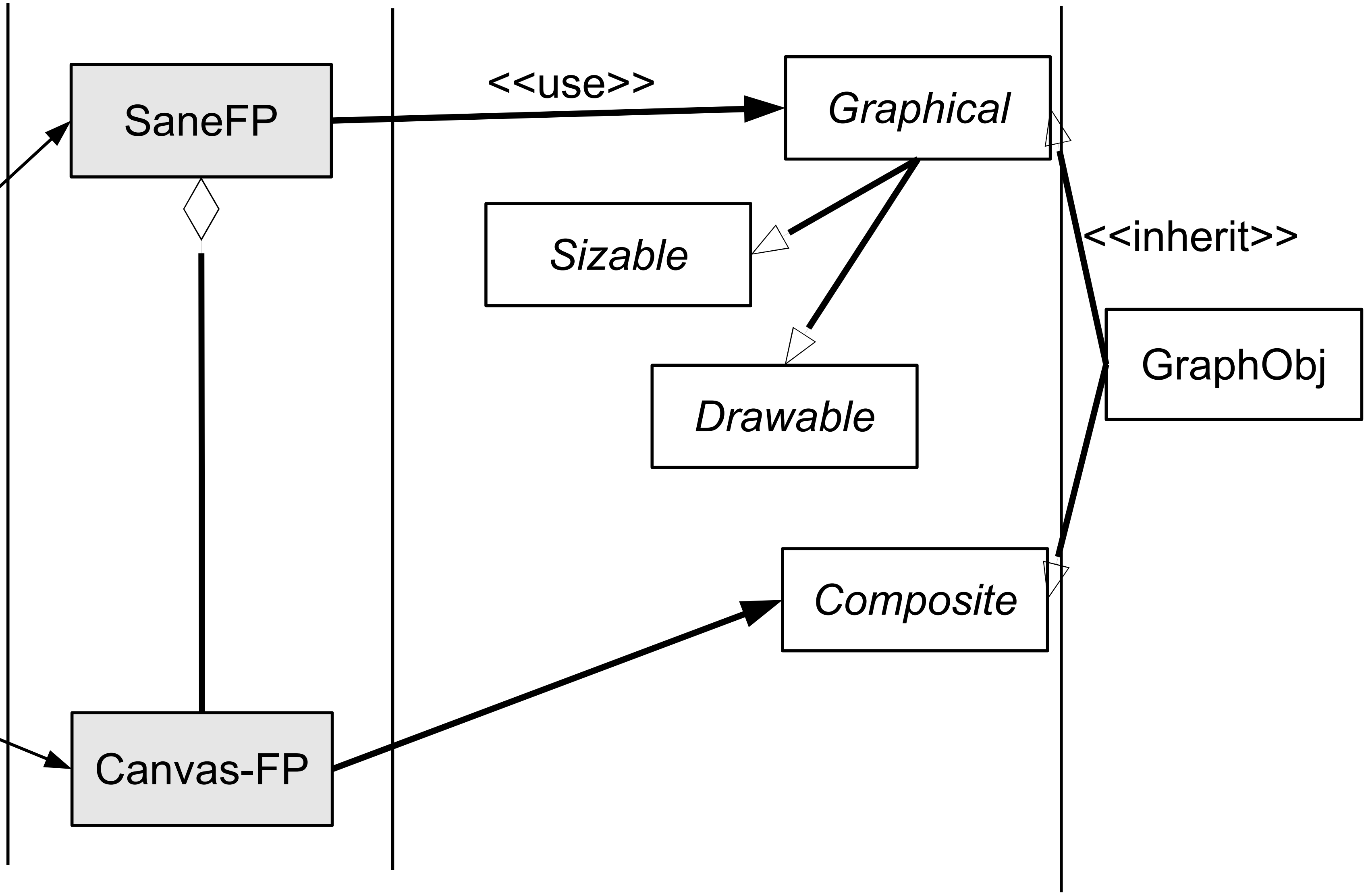
Interaction Part (IP) and Functional Part (FP)

- FP create a new layer



How TORA Tools Access Their Material

- Tool Sane is split into IP and FP
  - Manages a frame on the screen for drawing

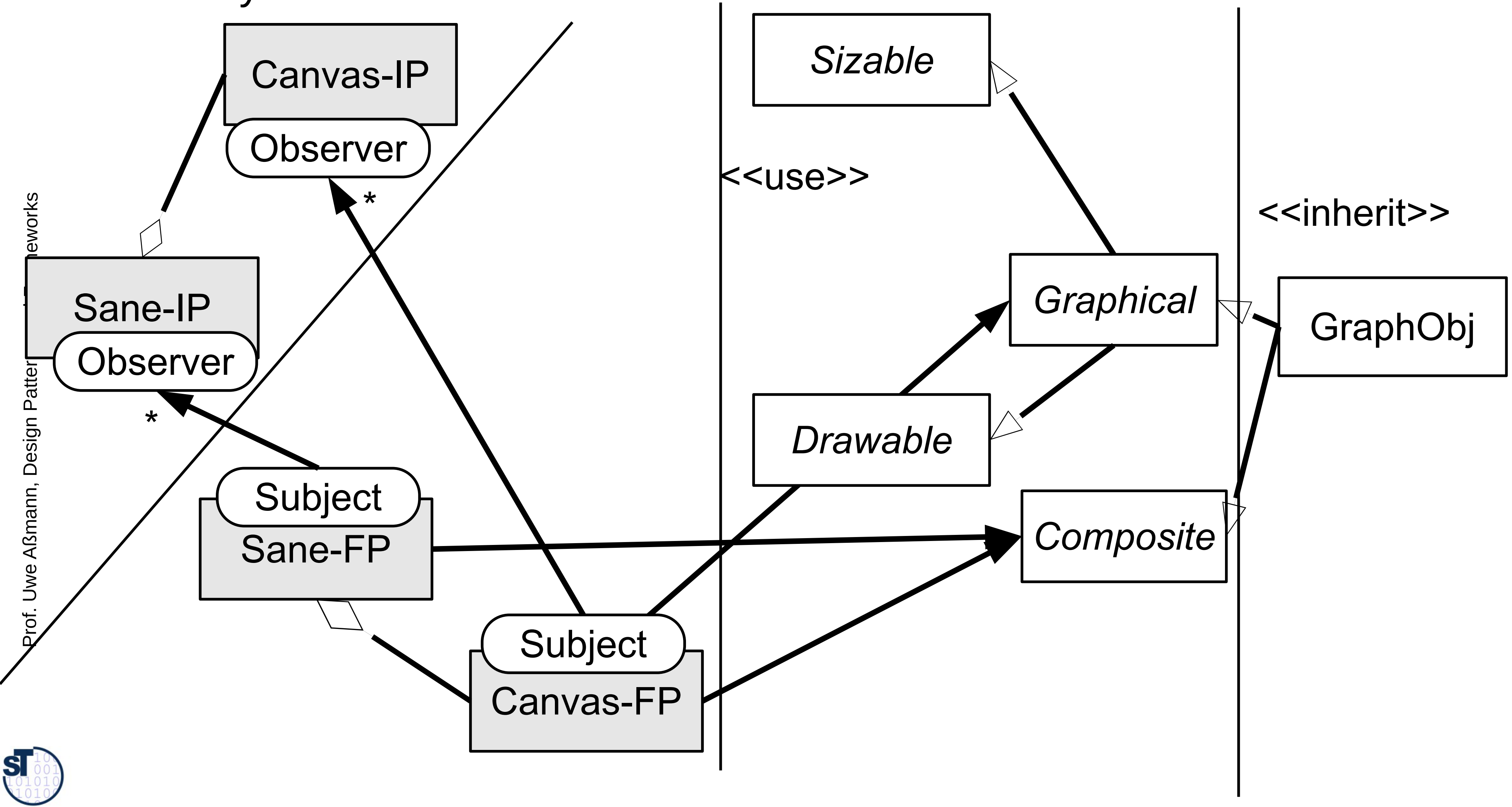


IP-FP TAM Refines MVC

- Tools contain
  - a view (IP)
  - the controller (FP)
  - and the managing part of the model
- The model is split between tool-FP, material access, and material

Coupling between Function and Interaction With Observer

- Play-Out via Observer pattern: IP listen to FP changes and actions
- Play-In via call

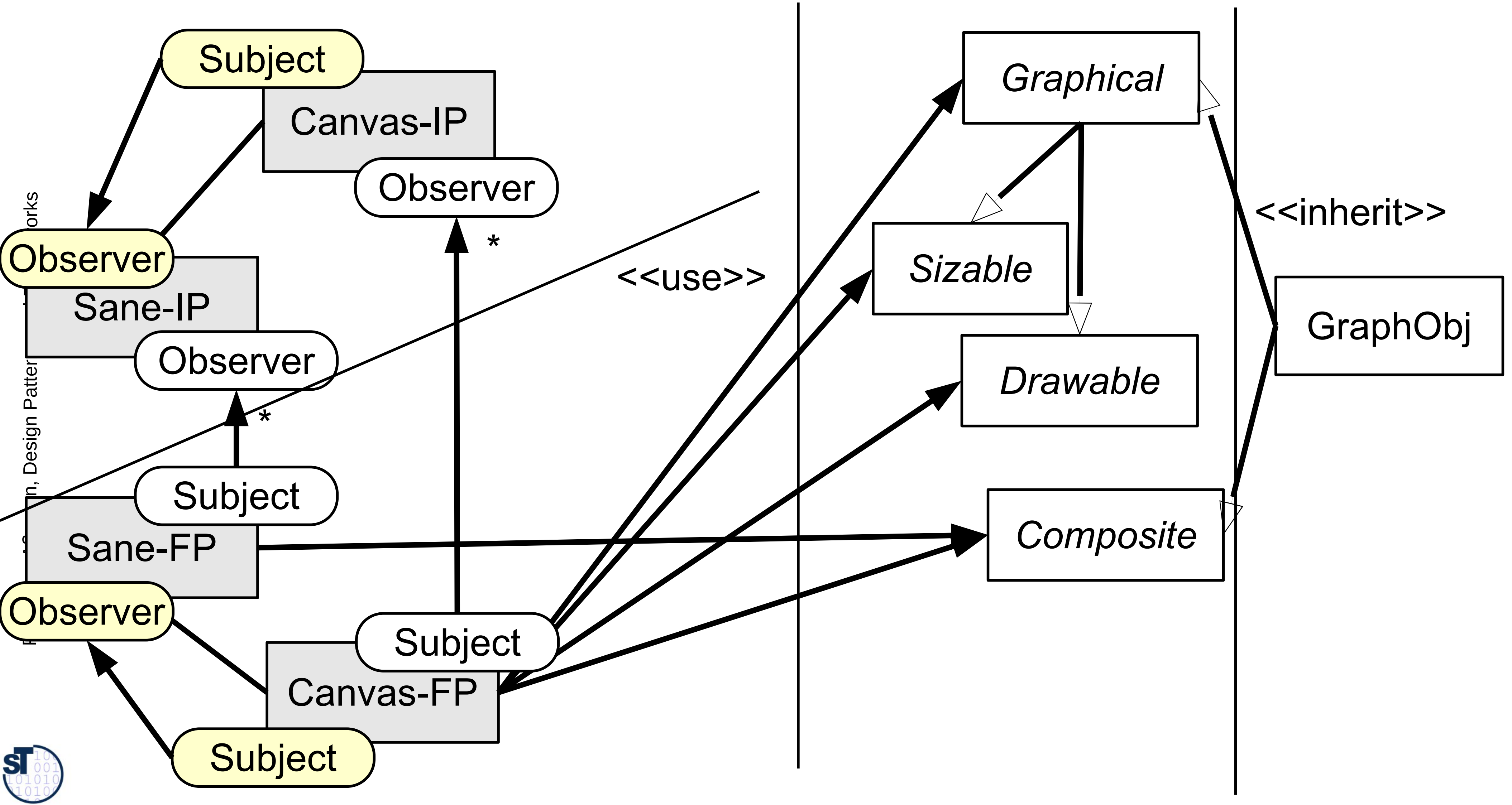


Coupling between Subtool-FP and Supertool-FP

- **Vertical tool decomposition** by structuring into subtools with Bridge, Composite, Bureaucracy
- **Horizontal tool decomposition** into IP and FP
- How to add new subtools at runtime?
  - Decomposition should be extensible
    - Vertically: for Composite, this is the case
    - Horizontally, Observer serves for extensibility
  - Communication should be extensible (next slide)

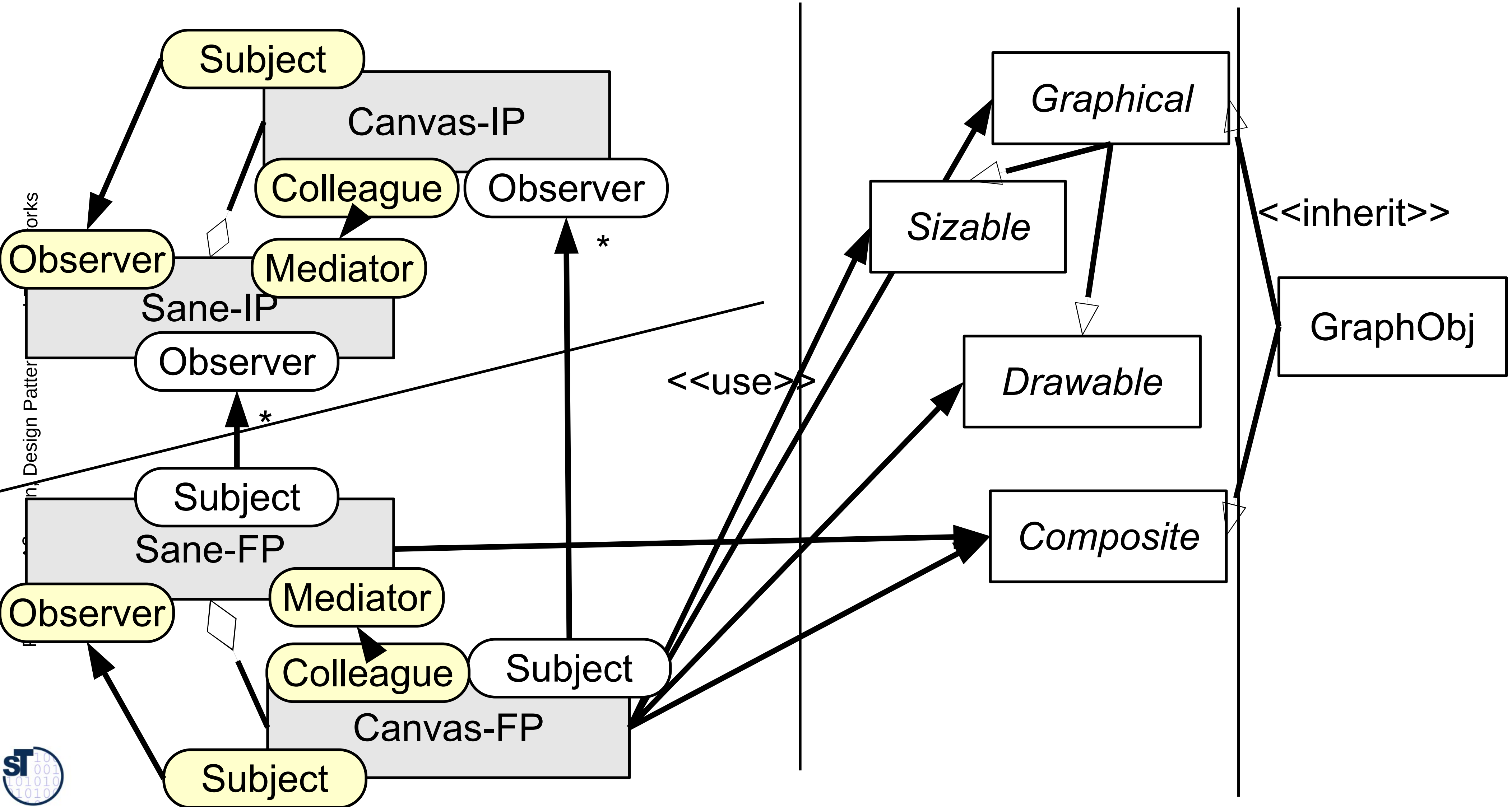
Symmetric Coupling between Subtools and Supertools by Observer

- Vertical Observer: Supertools are notified from subtools if something changes



Coupling between Subtools and Supertools By Symmetric Bureaucracy

- IP and FP hierarchy can work with a Bureaucracy each

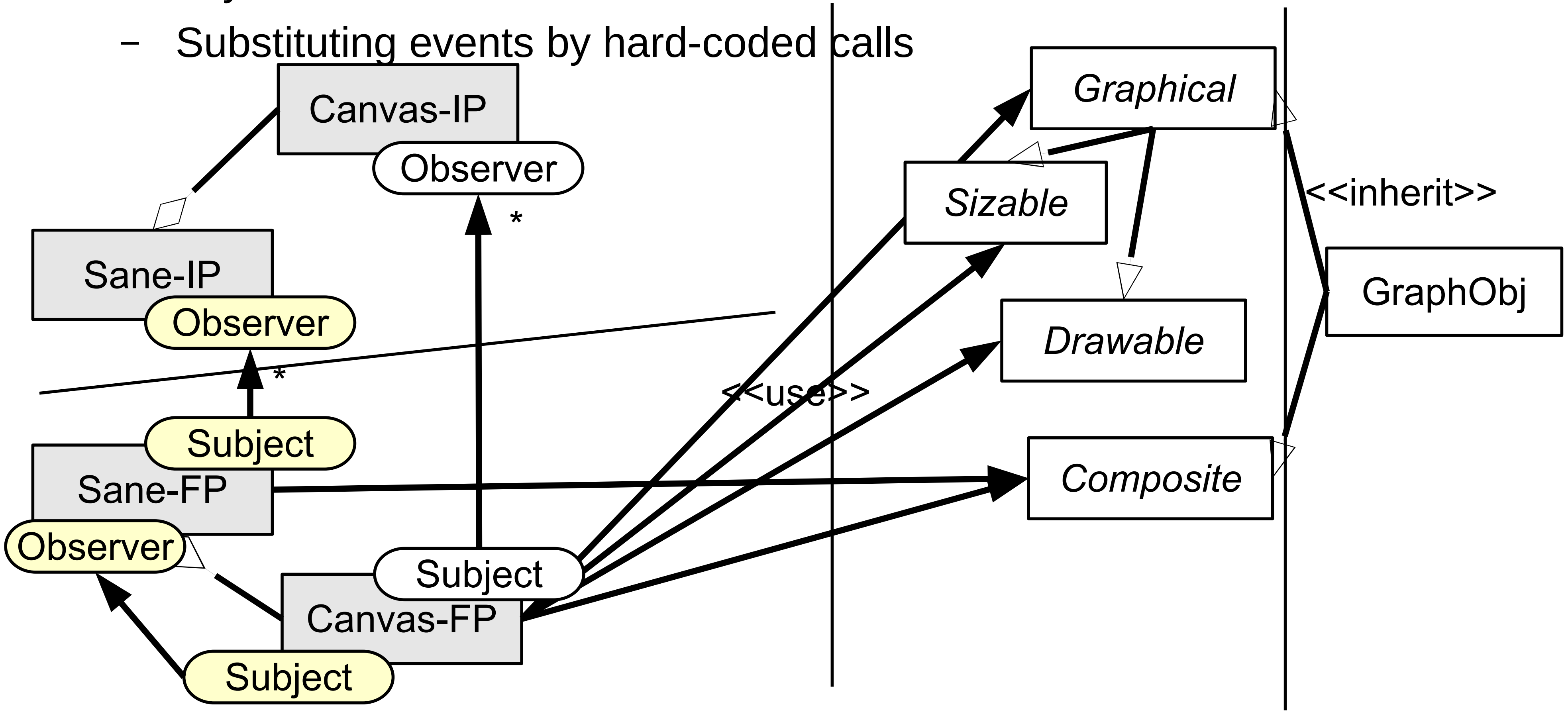


Creation of New Subtools

- Initiated by a Super-FP, which decides to create a new sub-FP
- Steps:
  - Super-FP notifies Super-IP
  - Super-IP may create one or several sub-IP
    - Connects them as observers to the sub-FP

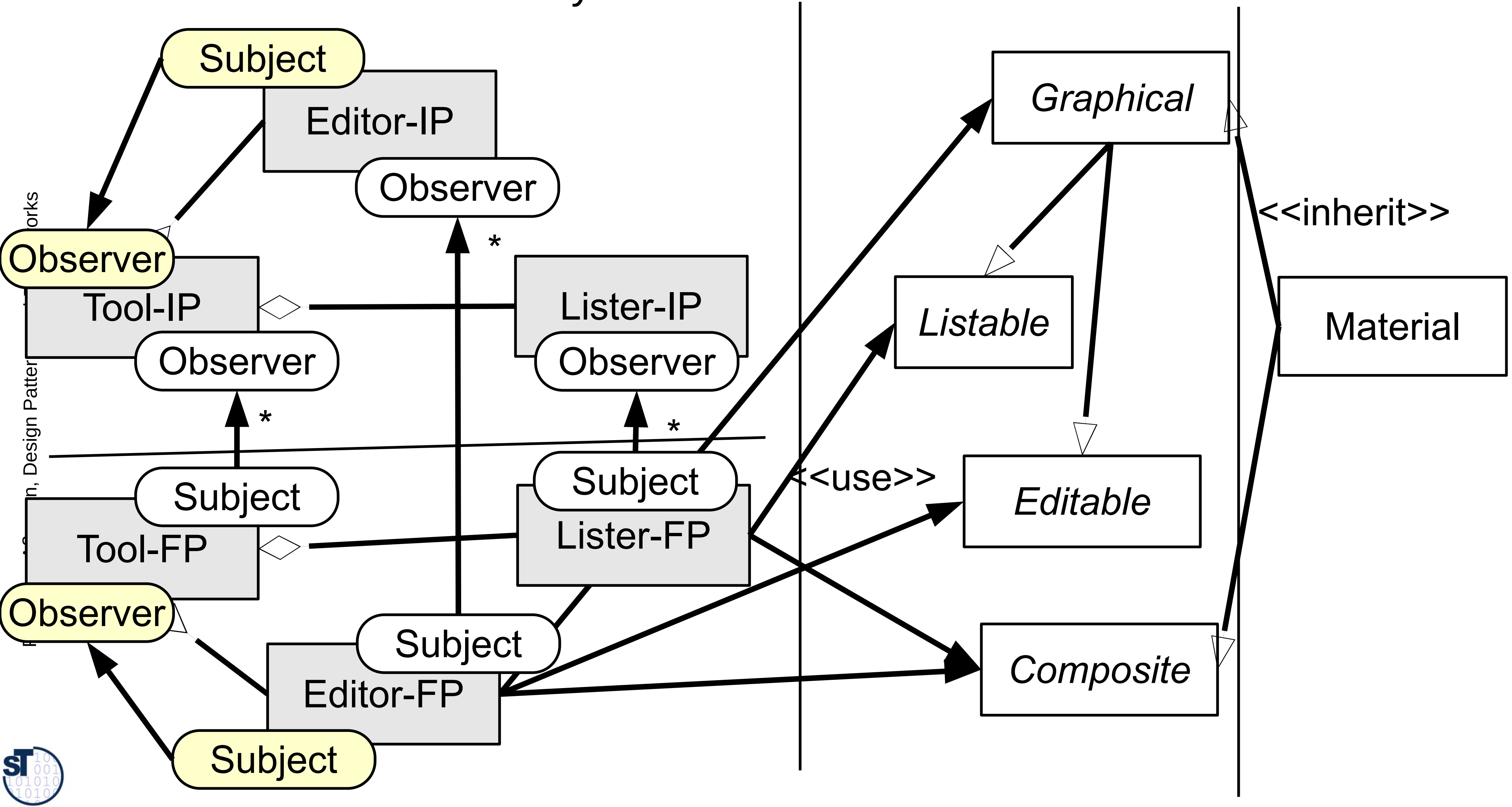
Non-Symmetric Coupling between Subtools and Supertools

- Super-IPs can be notified by Super-FPs
- Optimization: Several of the event channels can be coalesced for better runtime behavior
  - Merging FP and IP again, getting rid of Observer, but no extensibility anymore
  - Substituting events by hard-coded calls



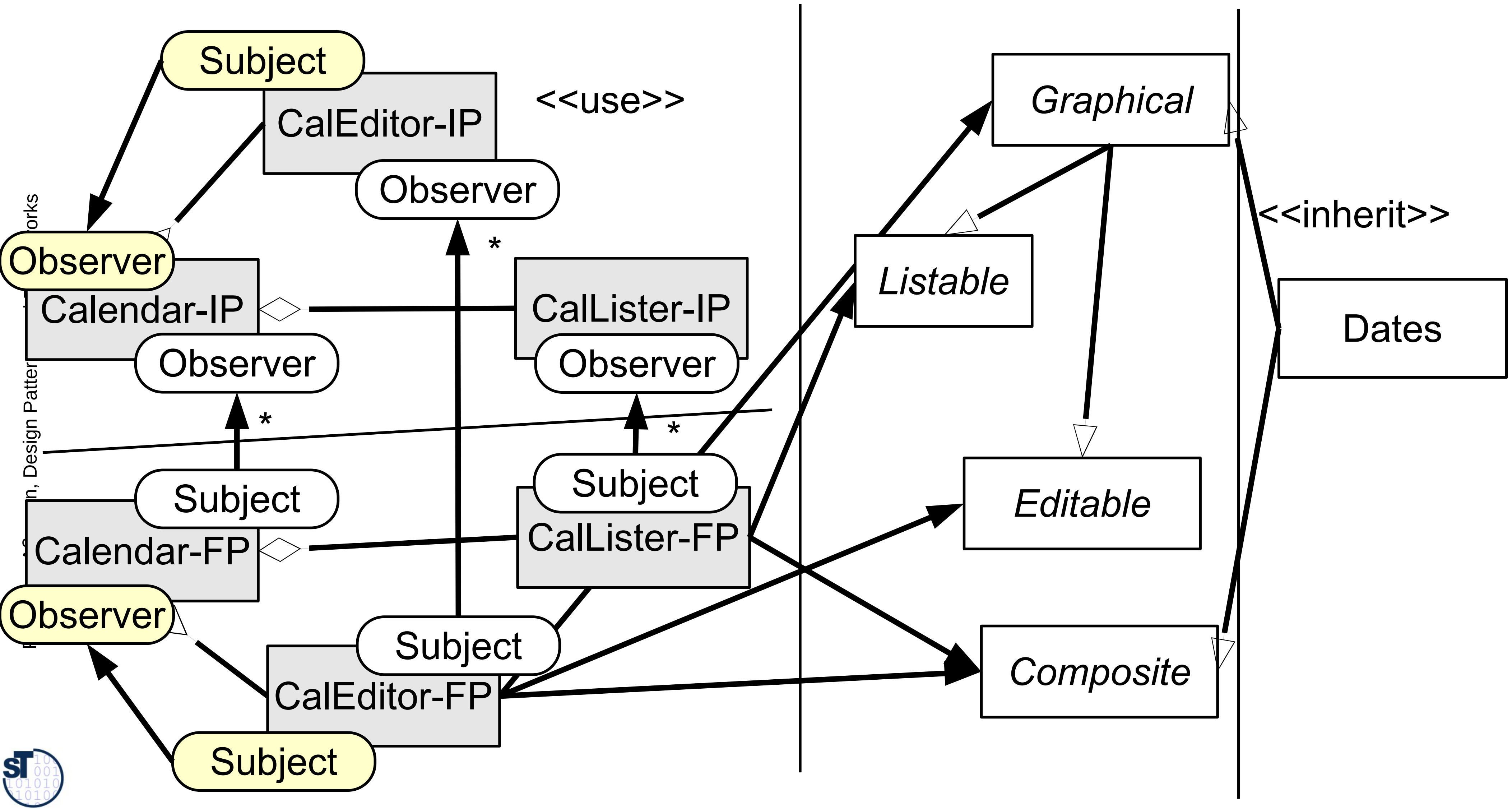
Example: Generic Editor and Lister Framework

- Supertools are notified from subtools if something changes
- Can be used for every editor and lister of material

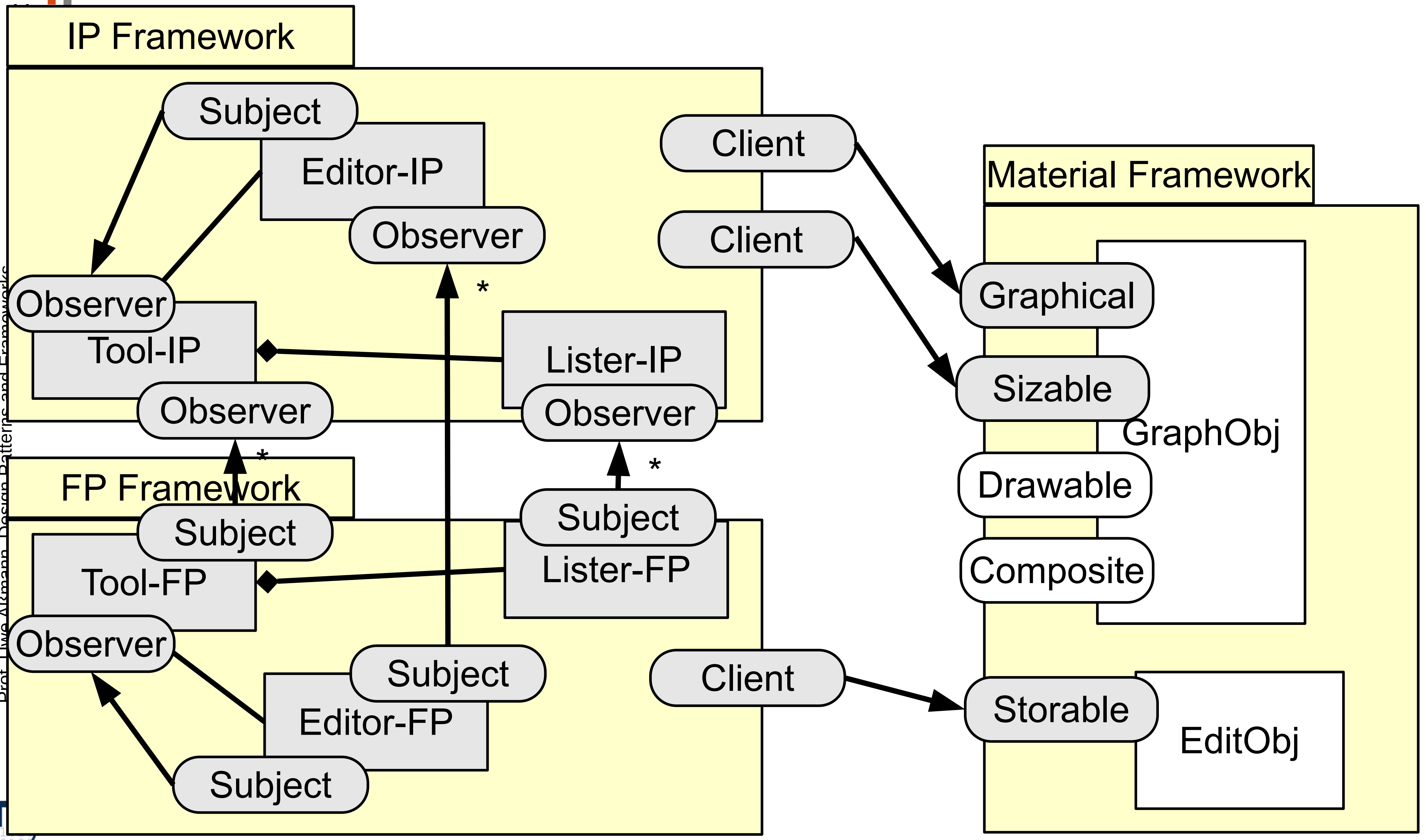


Instantiated to a Calendar Editor and Lister Tool

- Supertools are notified from subtools if something changes



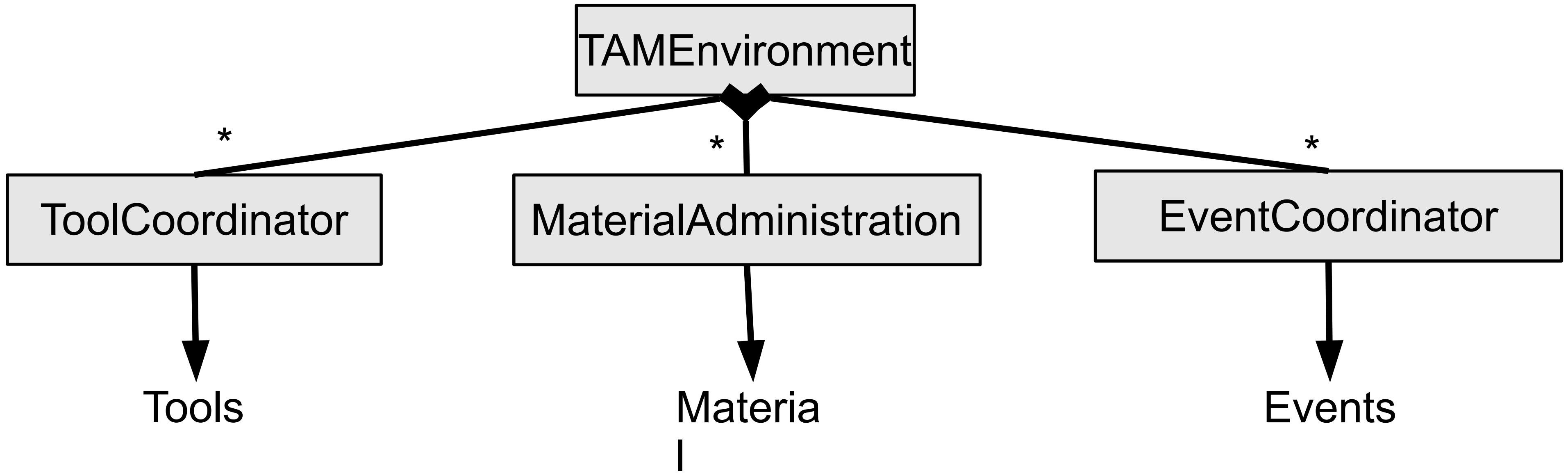
The Generic Editor in Framework Notation



14.3 TAM Environment

The Environment

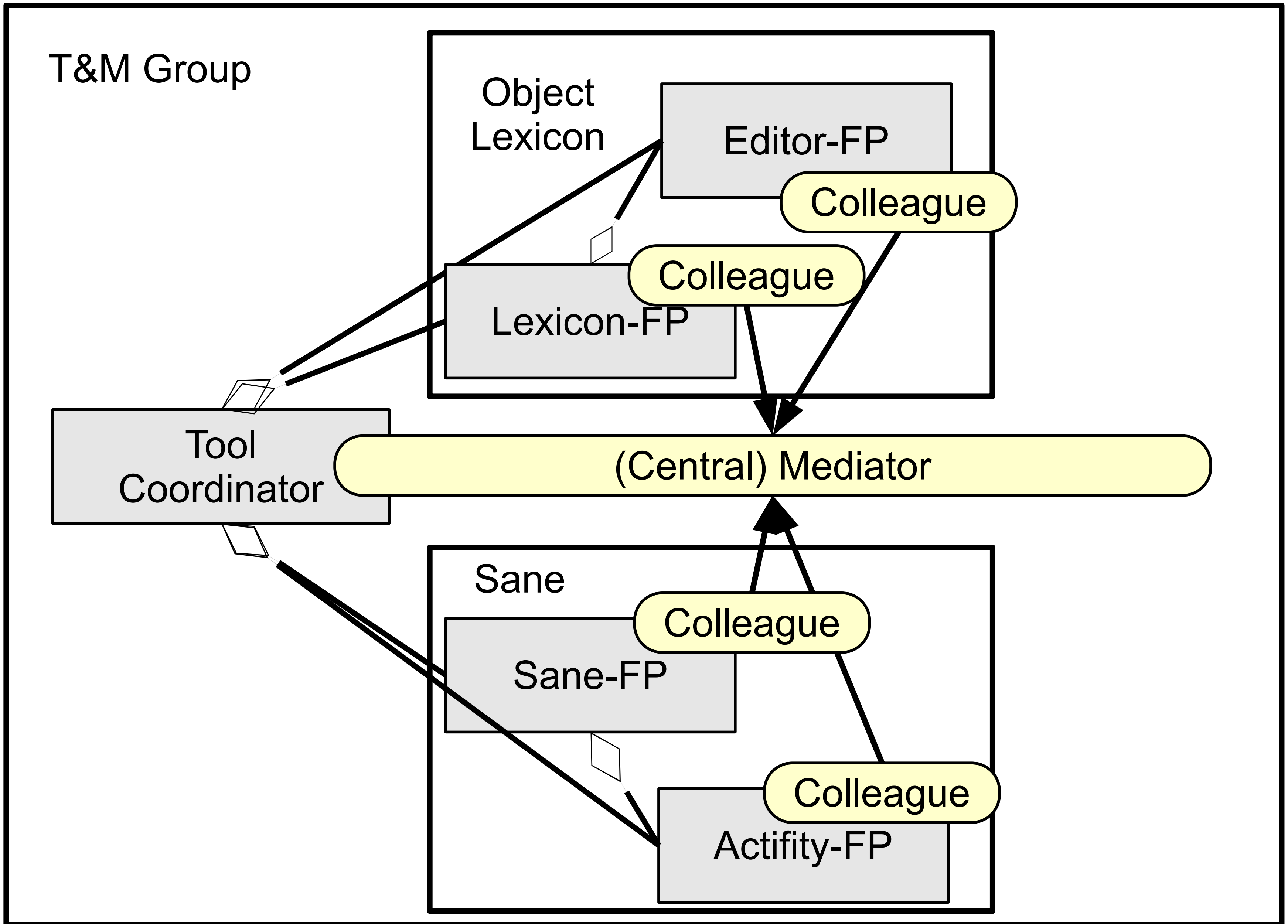
- Tools and Materials live in an environment with
  - Tool coordinators
  - Material administrations
  - Event coordinators
- The environment initializes everything, displays everything on the desktop, and waits for tool launch



Tool Coordinator in the Tol Environment

- The **Tool Coordinator** is a global object
  - Groups a set of tools and their related material
    - Contains
      - A Tool-Material dictionary of all tools and the materials they work on
      - A tool factory
- Is a Mediator between FPs and other tools
  - Usually, FPs talk to their supertools and their related IPs. When materials depend on other materials in complex ways, other tools have to be informed
  - The ToolCoordinator uses the Tool-Material dictionary to notify tools appropriately

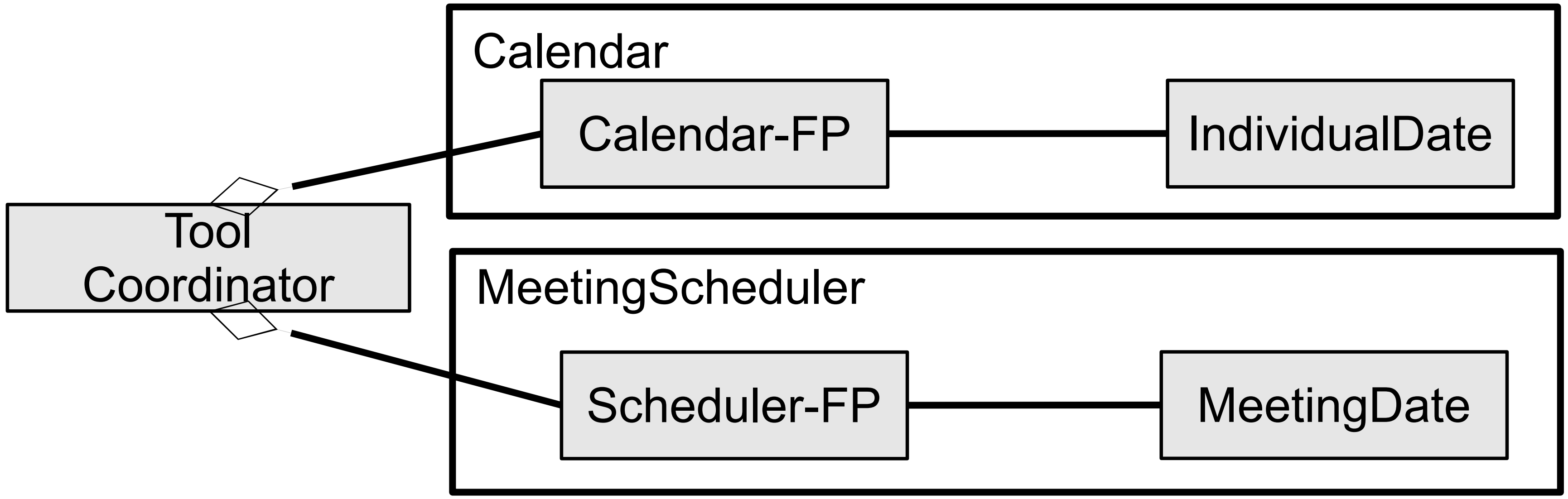
Example: TORA Tool Coordinator



14.3.1. Pattern: Constrained Material Container

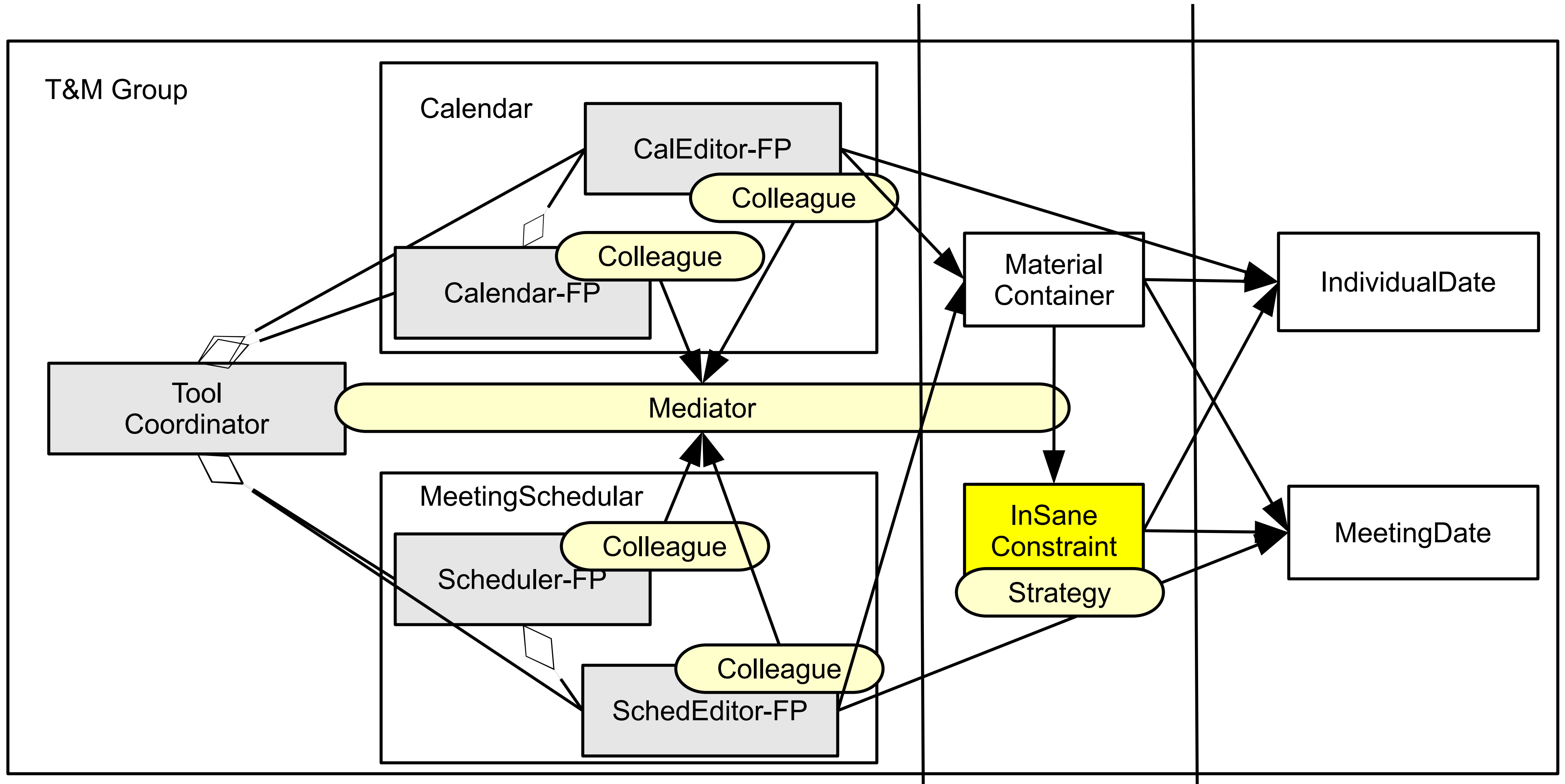
Problem: Dependencies Among Materials

- Materials may depend on each other
- Example MeetingScheduler
  - Maintains regular meeting dates (week, month, year)
  - Should collaborate with the Calendar tool that maintains individual dates
- Clearly, these materials are dependent on each other
  - The Calendar tool should take in meetings as individual dates
  - The MeetingScheduler should block meetings if individual dates appear in the calendar



Pattern: Constrained Material Container

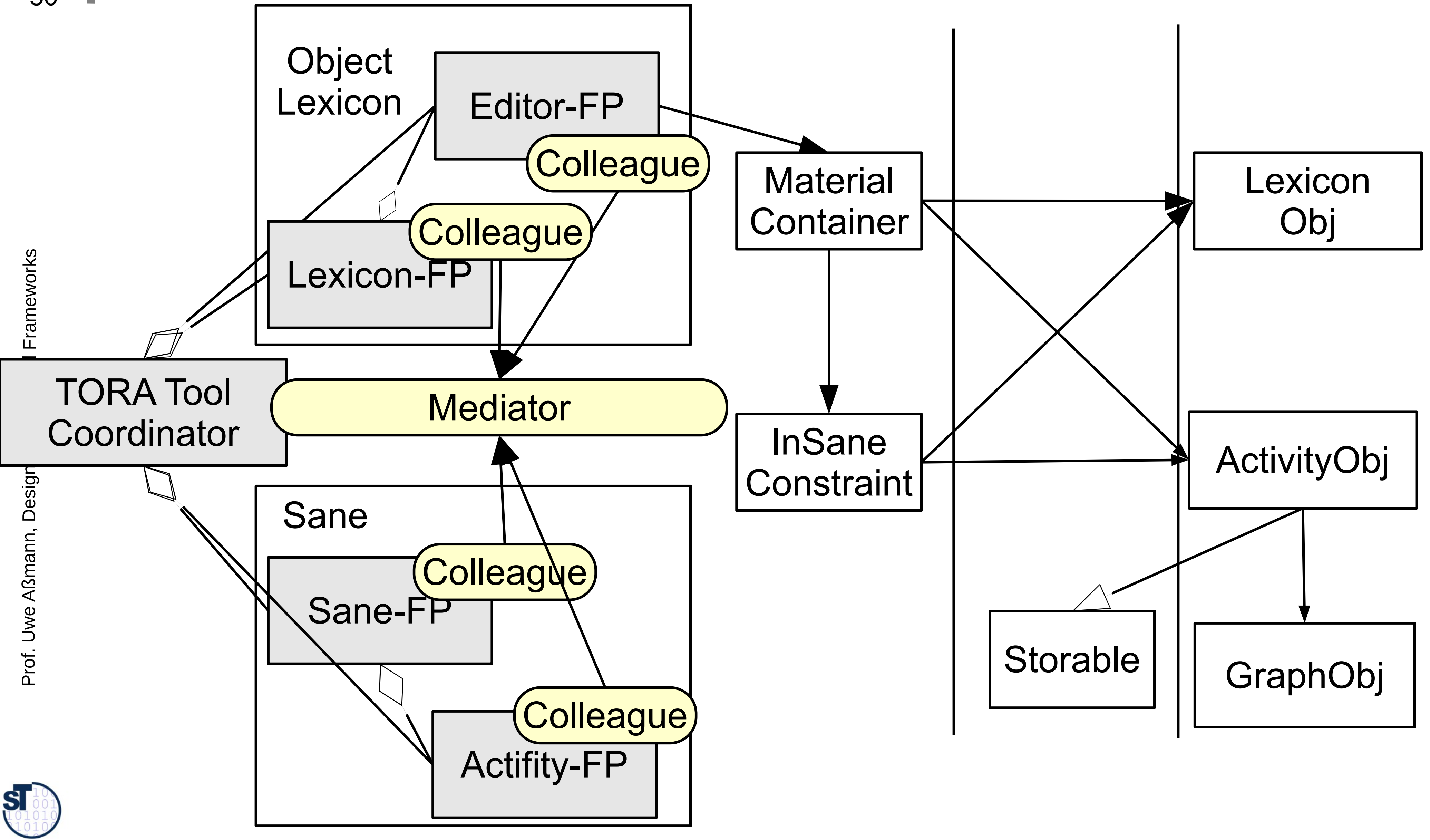
- We group all material that depend on each other into one *Material container*
  - And associate a *constraint object* InSaneConstraint that maintains the dependencies
  - The constraint object is a Strategy for controlling the dependencies of the Material



Tool Coordinator and Material Container

- Unfortunately, Constrained Material Containers of the group must query the dictionary of the Tool Coordinator,
  - to know about the currently available tools, to activate constraints
  - (which introduces an ugly dependency between them...)

Example: How TORA Tools Access Their Material



TORA Material Constraints

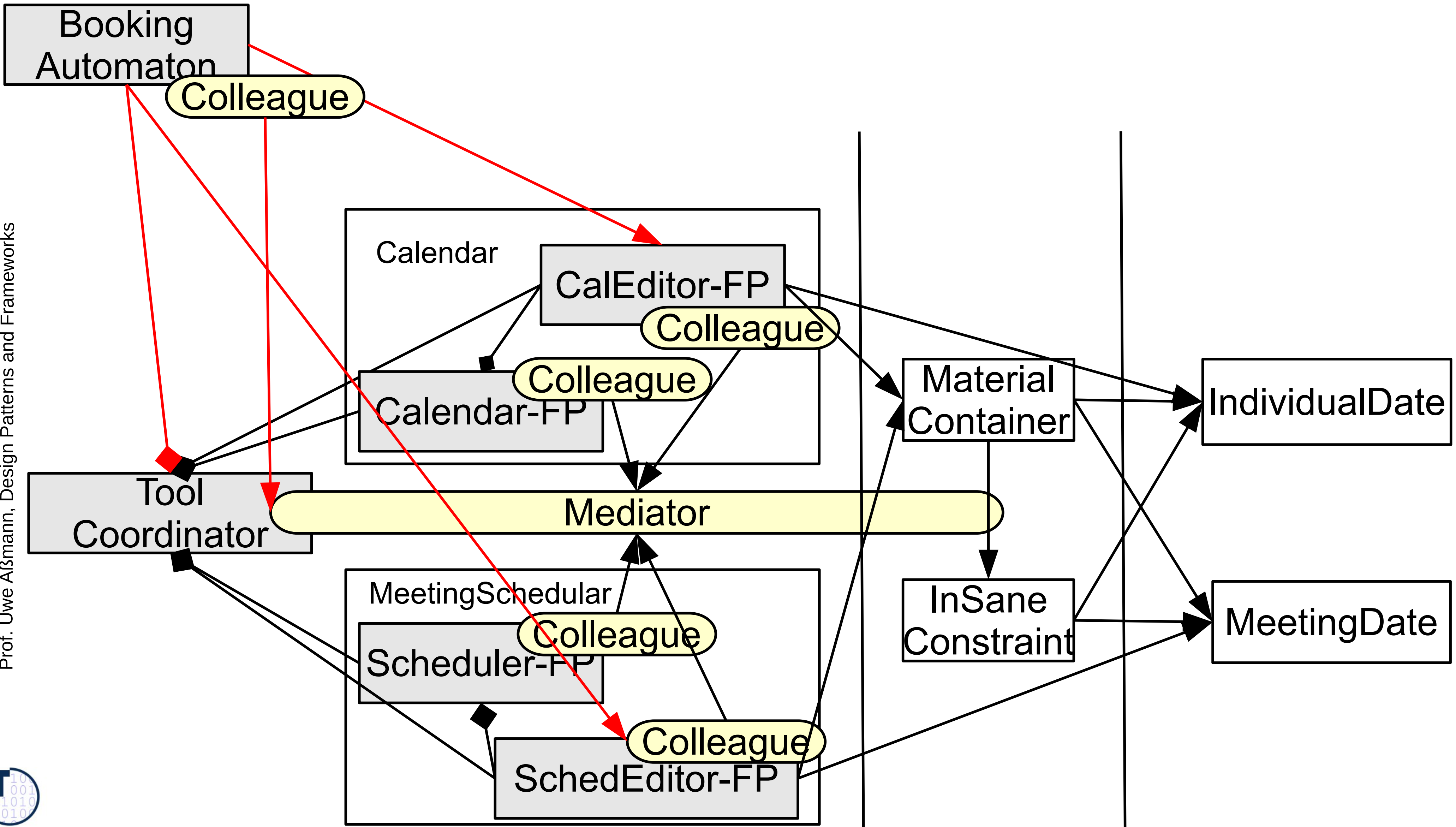
- For each ActivityObj, there is a LexiconObj
  - The user can textually edit the LexiconObj to document the ActivityObj and the GraphObj
- All Materials are in a MaterialContainer
  - Uses a ConstraintObject InSaneConstraint to make sur that the label of the ActivityObj is always the same as that of the LexiconObj
- If an ActivityObj is created, deleted, or changed, the tool coordinator is informed
  - And informs all related tools of TORA
  - The tool coordinator is a mediator

Automaton

- An *automaton* (*interpreter, workflow engine*) is an automated tool for repeated tasks
  - Similar to a macro-tool, a variant of Design Pattern Interpreter
  - Can run in the background
  - Often realized as separate machine processes
- An automaton encapsulates an automated *workflow* (or *process*)
  - Production of a complex artifact
  - Storing a complex technical object
  - Producing data in different versions
- Workflow can be specified by statecharts, activity diagrams, data-flow diagrams, Petrinets, workflow languages

An Automaton Booking Calendar Dates

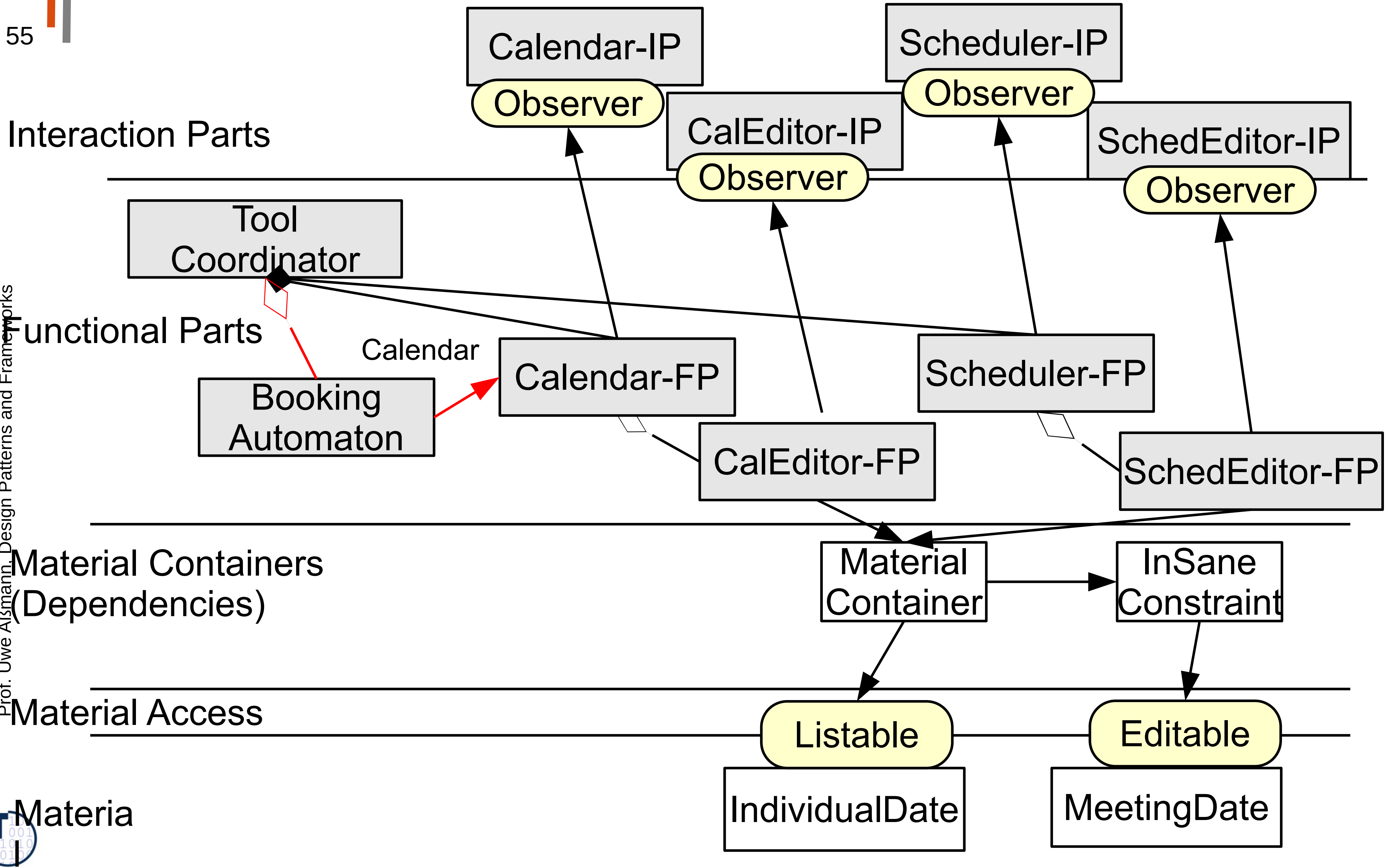
- The Automaton books regular meetings as dates into the calendar



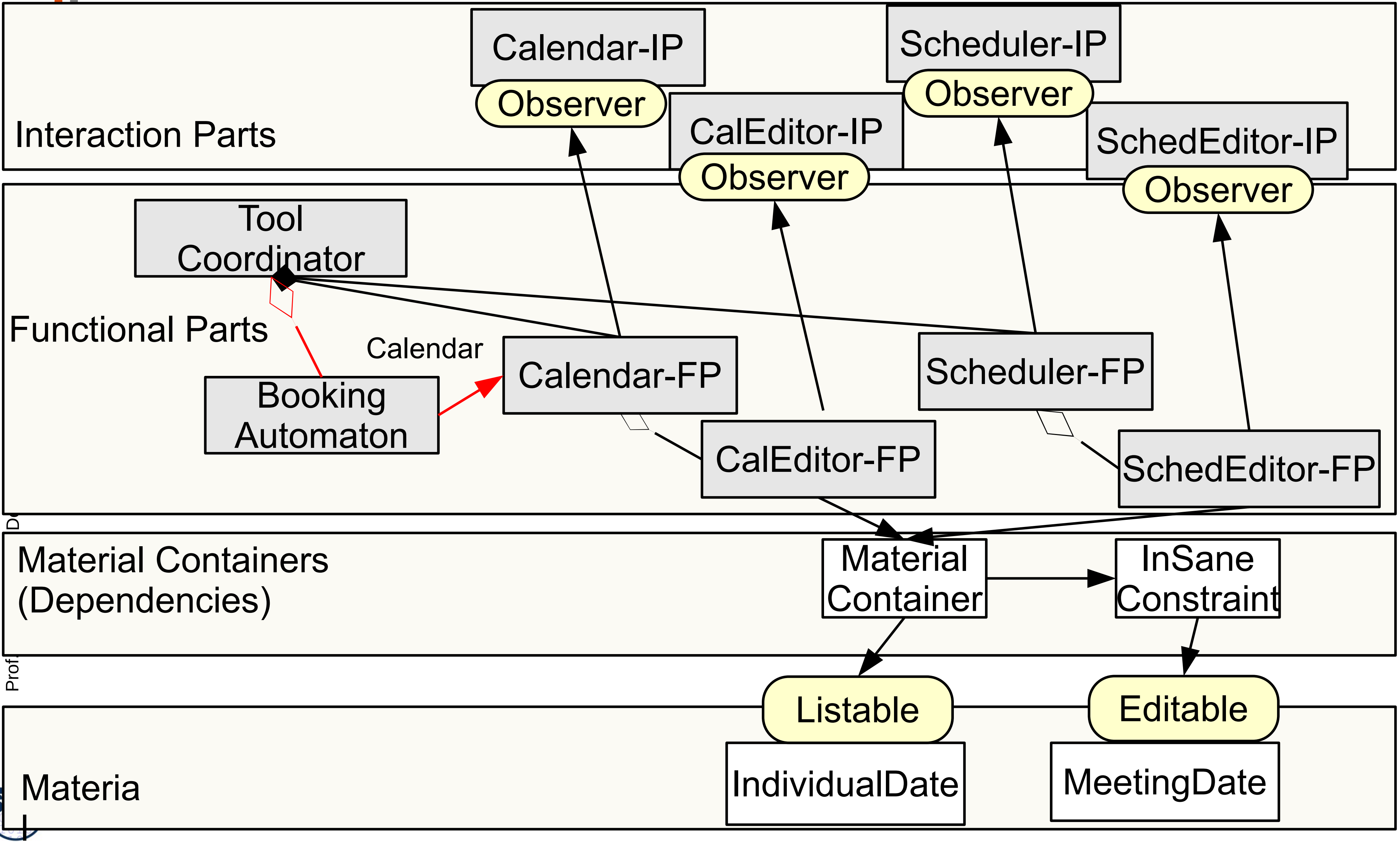
14.4 TAM and Layered Frameworks

Now, let's order the patterns of TAM into layers
What happens?

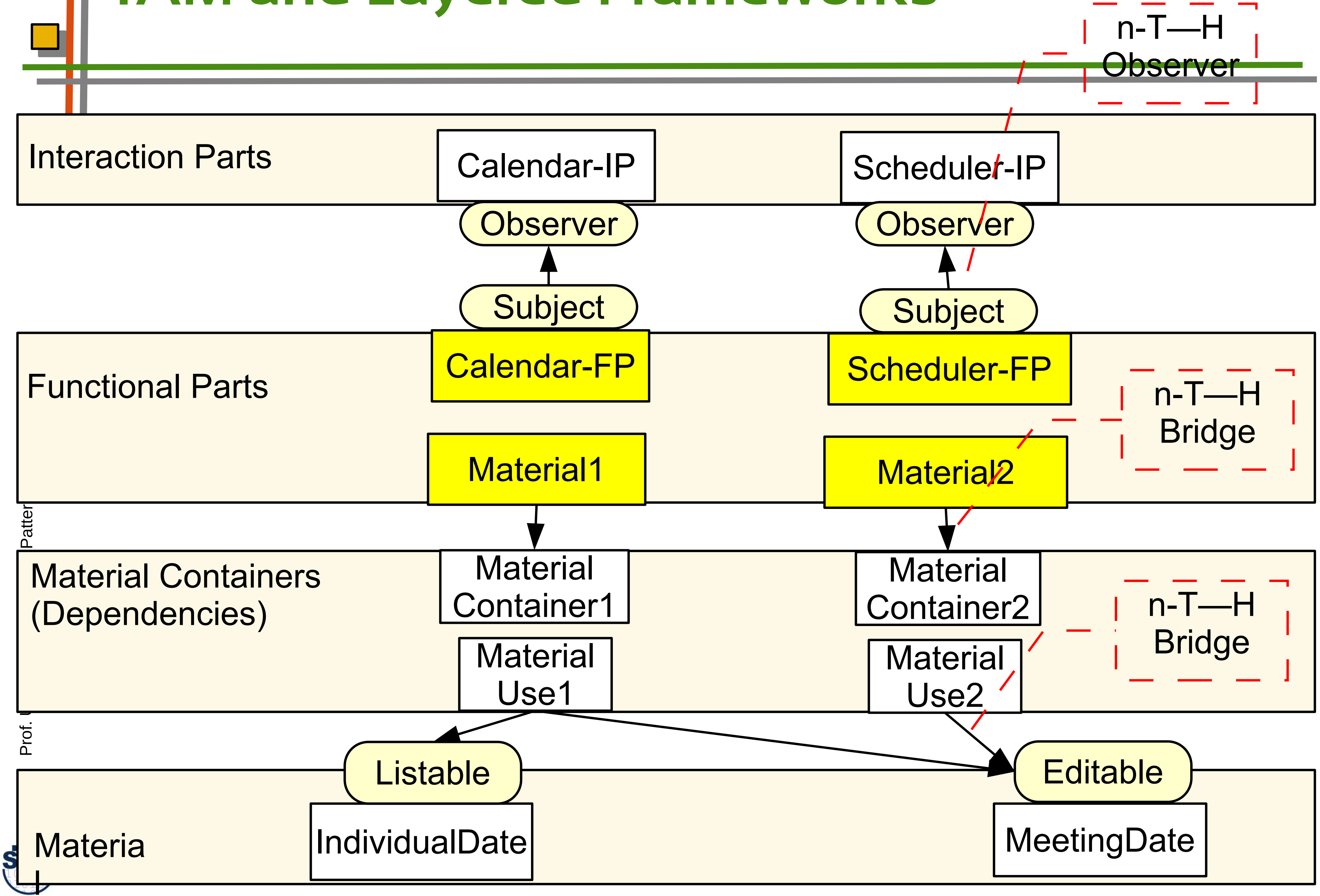
TAM and Layered Frameworks



TAM and Layered Frameworks



TAM and Layered Frameworks



TAM Is a Variant of a Layered Framework

- Combining different miniconnectors between the layers
  - n-T—H Observer between IP and FP
  - n-T—H Bridge between FP and MaterialUse
  - n-T—H Bridge between MaterialUse and Material, with roles as access for material
- Hence, interactive applications can be seen as instances of a layered framework
  - That uses not only RoleObject as mini-connectors, but also Observer and Bridge.
  - Hence the analogy to 3-tier
- This gives hope that we can construct layered frameworks for interactive applications in the future!

Summary

- The T&M conceptual pattern is a very important pattern for object-oriented development; all classes fall into these categories
- T&M is a pattern language for constructing interactive applications
  - Refines 3-tier and MVC
  - Uses Command, Strategy, Observer, Composite, etc.
  - Defines several new complex patterns such as Separation of IP and FP
- TAM is a variant of a layered framework, using n-T—H miniconnectors (Observer, Bridge) between the layers
  - Pree's framework hook patterns play an important role

The End