Lecture 2 Software Architecture Model

- Evolution of S/W Architecture
- S/W Architecture Concept
- Key Attributes

一、Evolution History

- Early days: a series of execution codes that use computing logics and algorithms from the program start to the end
- Then people found, to the large-scale s/w systems, the architectural design is more important than data structure and algorithm
- Experienced programmers tend to use certain types of architectural designs, yet no models or design standards that can follow

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- S/W architectural design originated from software engineering and borrowed a lot concepts from computer systems， and become a separated research field
- Topics include architectural description, architectural style, architectural design evaluation and formal approach to s/w architectural design
- Targets: Reuse of architectural design, design optimization, and s/w performance assessment

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1、No-architecture Stage（1946～1969）

- Programming languages: machine code and assembly language, emerge of advanced languages such as FORTRAN and COBOL
- Programs were small and simple, without considerations on s/w architecture
- Hardware system was simple, too, and s/w systems are mainly centralized
- S/W was bonded to h/w platform without importability

2、Infant Stage (1970～1980)

- Majority were advanced programming languages
- Software Engineering was initiated and researched, and development models, methodology and SDKs were developed
- The preliminary design and detailed design were conducted to guide building a s/w system, based on the schemes of control flow and data flow

3、Junior Stage(1980～1990)

- Appearance of large-scale s/w systems and the object-oriented technology, which allowed the designer, developer and user to more precisely present their design work, which greatly improved the quality of s/w products
- In 1994, Booch、Rumbaugh、Jacobson invented the Unified Modeling Language (UML)
- S/W architectural design draw attentions

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4、Advanced Stage (since 1990)

- S/W systems become more and more complex and larger scale
- Algorithm + Data Structure converted to Component + Architectural Assembly
- Advanced abstraction: decouple Arch. Model from Arch. Design (Kruchten's "4+1" Model)
- No unified definition, no widely accepted standards yet

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S/W Arch Model – the formal description of software architecture

- S/W Architecture: can be rebuilt and pre-made software framework
- **Component:** can be reused and pre-made s/w units, work as the basic computing units or data storage blocks for software systems
- **Connector:** also a reused and pre-made s/w unit that can provide connection between components
- **Constraint**: the relationship between the components and connectors

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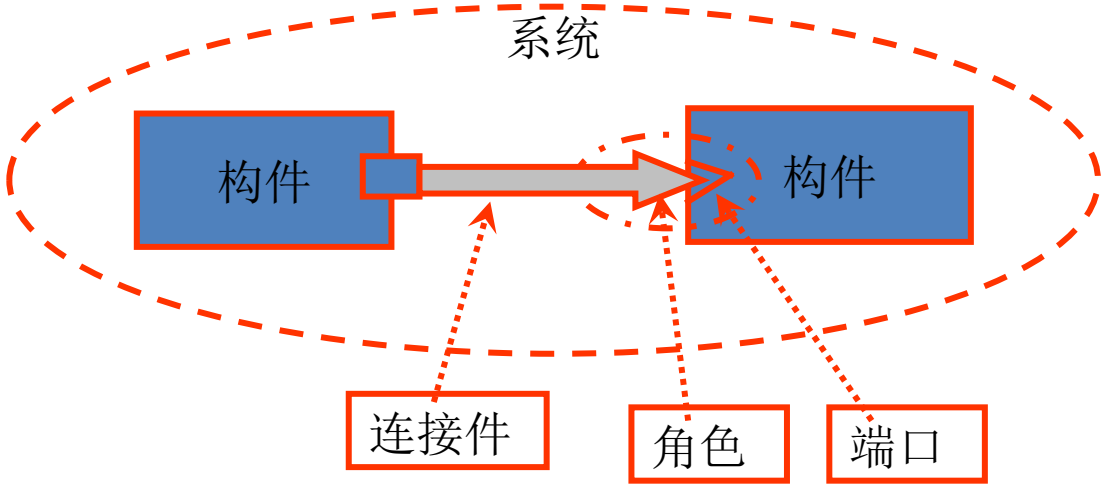
Architectural Model Core consists of

- Components
- Connectors
- Constraints



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- Component: as an encapsulated s/w instance, with the interface interacted with external systems.

  Component interface consists of a set of ports, serving as the interacting points with others

软件架构模型

- Connector: as one key block of software architecture, it also has the interface.

  Connector interface consists of a set of Roles that defines the parties involved in the interaction of the connection.

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Formal presentation

- S/W Architecture ::= Core Model | Arch Style

  Core Model ::= (Component, Connector, Constraints)

  Component ::= {port1, port2, …, portN}

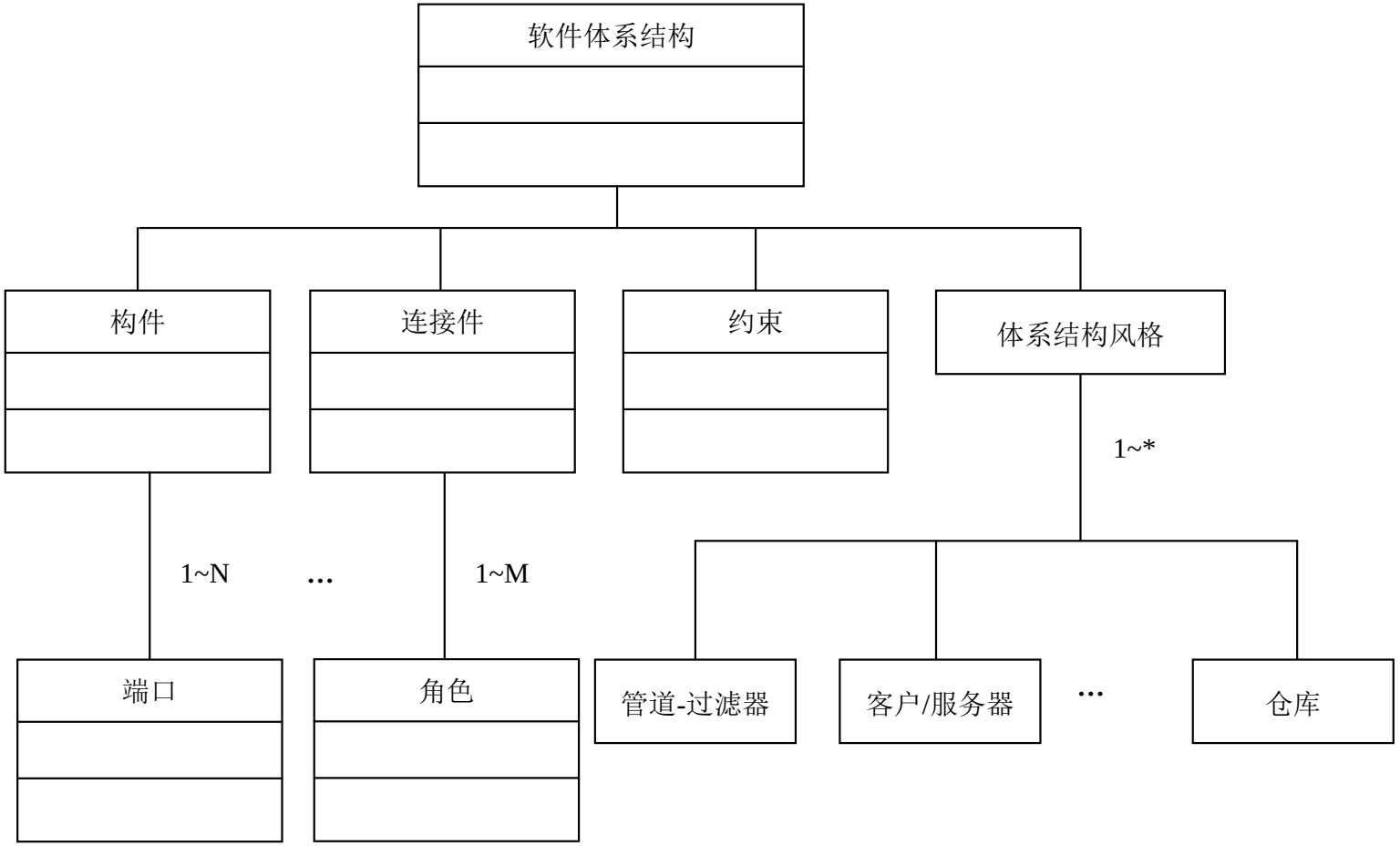
  Connector ::= {role1, role2, …, roleM}

  Constraint ::= {(porti, portj), …}

  Arch Style ::= {pipe-filter, client/server, DB, …}

软件架构模型

A Formal Presentation of S/W Arch in Graph



Arch Attribute Details - Component

- Can be as small as a process/thread, and as large as an application, can be a function, an object, a process, a binary instance, a class or a data block
- Independent to each other, with inside details encapsulated and service provided through well defined interface
- Mechanism contains the attributes of ports, type, semantics, constraints, evolution and non-functional properties

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- Principles for Component Composition
  - ✓ Components joining the composition keep their independence， which leads to the composite component having advantages of better re-use and better evolution behavior
  - ✓ Composition shall be realized through using of external units, such as connectors. Composition contains the interaction among components, not just a list of components
  - ✓ Component Decoupling – an opposite operation, will explain later

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Connector’s Formal Definition:

（*ID, Role, Beha, Msgs, Cons, Non-func*）

ID: connector’s identifier

Role: a set of roles

Beha: a set of behavior definition

Msgs: a set of messages associated to connector

Cons: a set of constraint conditions, including initialization, pre-definition and post-constraint

Non-func: non-functional description of connector

Arch Attribute Details - Connector

- Used as the supporting blocks for component interaction and role realization
- Can be in the form of message/signal passing, function/method calling, data transfer/conversion, as well as process sync.
- Examples: pipe in Pipe-Filter, communication protocols in Client/Server, and SQL connection between the application program and database
- Interface of Connector: a set of Roles that serve as the interaction points and define the role and position of participating parties

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Key Design Attributes of Connector： extendibility, interoperation, dynamics and responsiveness

- Extendibility： allows the dynamic changes on the associated components and their interactions
- Interoperation： the connected components may directly or indirectly operate on other components through the connectors
- Dynamics： the connector may apply dynamic actions to the connected components
- Responsiveness: Concurrent and timing response by the connectors

Component vs. Connector

- To components, the connectors serve as a bond to support the interaction among components
- Similar to components, connectors are also building blocks of the software architecture, yet provide different functions or services
- Constraints describe and define the relationship and applying roles between components and connectors. Can be presented in a deployment scheme or a topology

Arch Attribute Details - Constraint

- Described as the rules and conditions
- Provides a boundary for architectural connection, in which connecting requirements for components, ports, communications are specified, and the behaviors are defined
- Bridges the software architecture to the system requirements through well defined and correctly designed connecting components

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Presentation of Architectural Model

Component Diagram, Connection Diagram, and Assignment Diagram

- **Component Diagram** describes the functions of each component and the relationship among them, including the division diagram, utility diagram, layered diagram, and class diagram
- **Assignment Diagram** shows the assignment of each s/w units in the building environment or execution environment, including the deployment diagram, realization diagram, and task assignment diagram

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- **Connection Diagram**, in which the components serve as the major computing blocks and the connectors provide encapsulated communication channels, including process diagram, concurrency diagram and data sharing diagram
- Above model diagrams provide the view of s/w architectural model from various angles, which can be used to measure the quality of architectural design

Software Architecture Life Cycle

- Non-formal natural language description of s/w architecture's life cycle of design, building, deployment, and measurement. Used in the early stage of software engineering by designers and engineers
- Formal specification of s/w architectural design and analysis through math model and formal definitions, which is more precise and regulated

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- Design, measure and improve --- a work cycle for building and optimizing software's architecture for large-scale software systems
- The analysis results or conclusions will be used to guide the architectural design, building and deployment of software systems
- The quality and performance measurement based on the architectural model and system outputs will be evaluated and reused in further improvement

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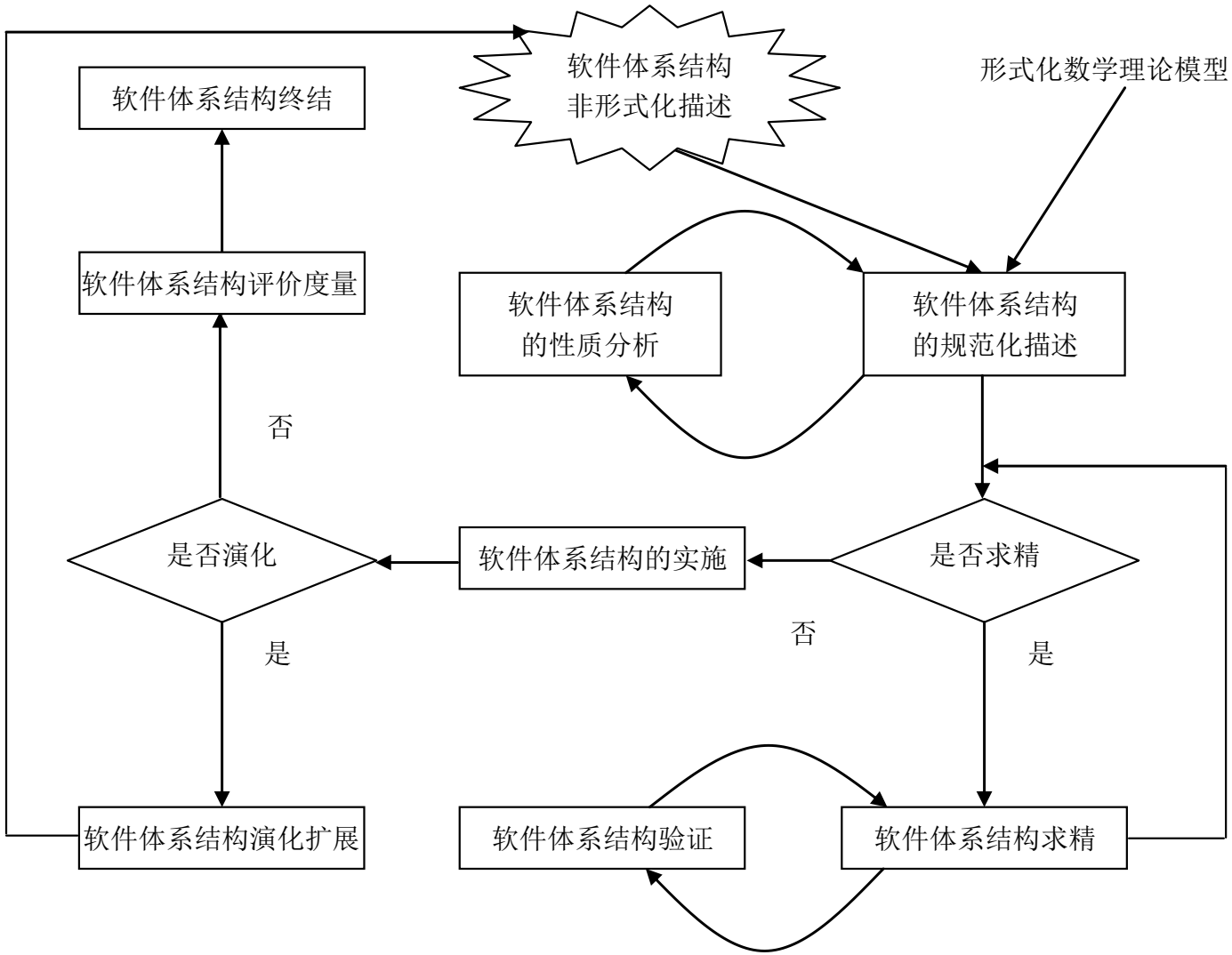
软件体系结构
非形式化描述
形式化数学理论模型
软件体系结构终结
软件体系结构评价度量
软件体系结构
的性质分析
软件体系结构
的规范化描述
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End of Lecture

Thanks!