Perspective-based Architectural Approach for Dependable Systems

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Perspective-based Architectural Approach for Dependable Systems

- ☞ **Overview**
- ☞ **Perspective-based Architecting**
- ☞ **Dependable Compositional Patterns**
- ☞ **Conclusion**

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☞ Objectives

- **to develop a method known as PBA[1]**
- **to incorporate rapid system prototyping (RSP)**
- **to build a synthesizing approach that enables**
  - ✓ **explicitly architecting HDSIS[2]**
  - ✓ **consistently engineering HDSIS**

[1] PBA: Perspective-Based Architectural Approach
[2] HDSIS: Highly Dependable Software-Intensive Systems

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☞ Barriers

- **Perspective confusion problem**
- **Model construction problem**
- **Constraint localization problem**
- **Software tool support problem**

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Perspective Confusion

Customer

Increased uncertainty about requirements

Architect

Flexible Configuration in Organization

Implementer

Rapid Application Development

They are not always coincident concerns for all stakeholders, sometimes they are even contradictory for customer, architect and implementer, respectively.

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Model Construction

Modeling a system against different perspectives should reflect different stakeholder’ s concerns, and it is required that these models are compatible

A transitional process can be applied to change one into the other with a dependability-conserved transformation.

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Constraints Localization

Dependable properties of HDSIS, such as *availability, reliability, integrity, security, maintainability*, **are generally translated into quantitative constraints**

How to localize these constraints becomes key issue because it is not easy to find the crucial formal argument on which constraints are localized

Software Tool Support

Intellectual models are to be represented as semantic formulas that is suitable for reasoning and manipulation by CASE tools and this will be the main challenge.

A well-formulated description provides the mechanism for reasoning and manipulation

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☞ Solutions

- **Modeling HDSIS via multiple perspectives**
- **Explicit architecture via compositional patterns**
- **Property formulation via localized constraints**
- **System evolution via generic framework**

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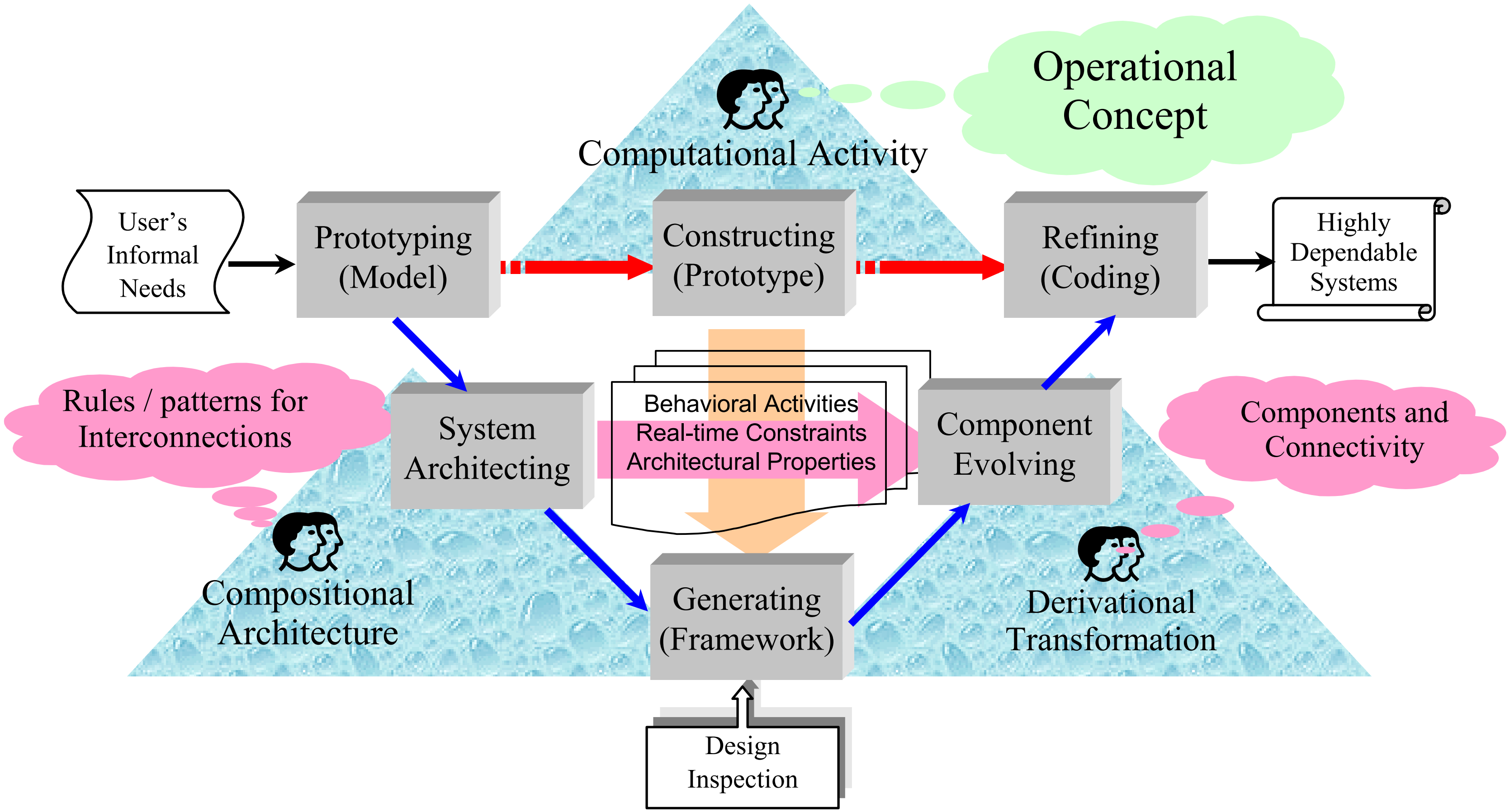
PBA: Perspective-Based Architectural Approach



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☞ Perspective-Based Architectures

- Computational Activity
- Compositional Architecture
- Derivational Implementation
- Transitional Procedure

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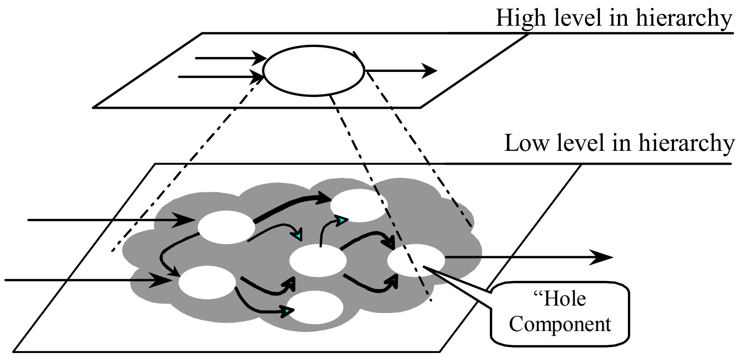
Computational Activity

Computational activity accounts for the customer perspective concerns of computation and interconnection

$$P_{\mathbf{computation}} = [C_c, I, Ct\ (C_c, I)]$$



Computational activity is used to capture the activities and information flows that will accomplish the operational concept

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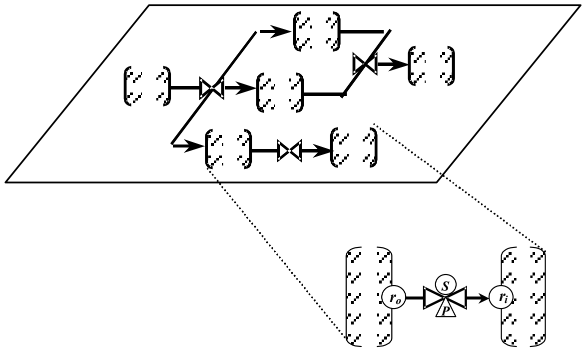
Compositional Architecture

Compositional architecture accounts for the architect's perspectives of explicit treatment of system composition and architecture with constraints localized on compositional patterns

$$P_{composition} = [C_c \Rightarrow R,\ R_o \xrightarrow{S/P} R_i,\ Ct\,(R, S, P)]$$



Compositional architecture provides a set of rules (patterns) that governs the interactions among components

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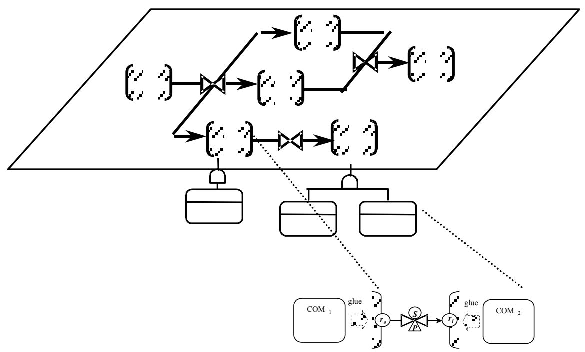
Derivational Implementation

Derivational implementation accounts for the implementer's perspectives of component derivation and connectivity

$$P_{\mathbf{derivation}} = [R \supset C_p,\ (C_p \rightarrowtail R_o) \xrightarrow{S/P} (R_i \leftarrowtail C_p),\ Ct\,(C_p\ S,\ P)]$$



Derivational implementation identifies physical components and connectivity that will be instantiated to carry out the computational activity

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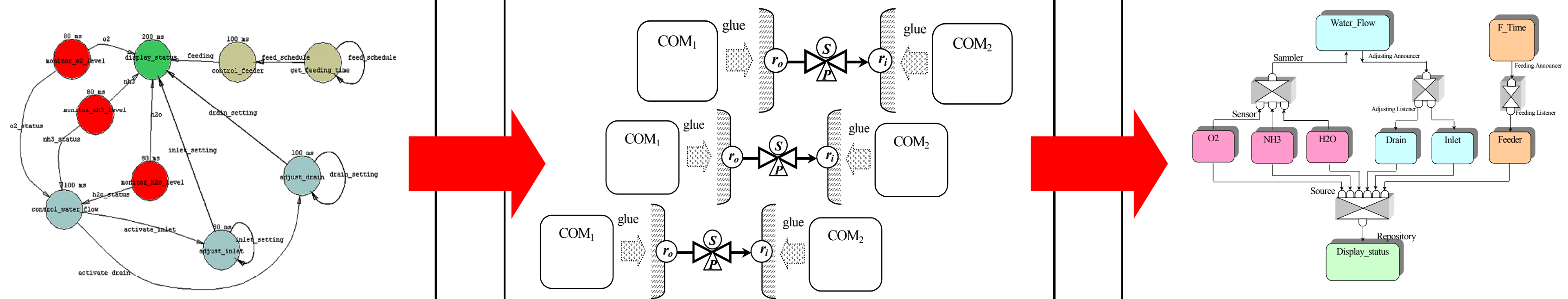
Transitional Procedure

P computation	Explicit Architecting via Compositional patterns	P composition	Physical Derivation via PBA composers	P derivation
C_c		$C_c \Rightarrow R$		$R \supset C_p$
I		$R_o ?^{S}/_{P}? \ R_i$		$(C_p \rightarrow R) ?^{S}/_{P}? \ (R \leftarrow C$
$Ct(COM, INT)$		$Ct\ (R, S, P)$		$Ct\ (C_p, S, P)$



Prototyping Analyzer | Pattern Selector | Framework Generator | Component Evolver

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☞ Dependable Compositional Patterns

- **Conceptual Model**
- **Formal Representation**
- **Substantiated Interconnections**
- **Dependability vs Constraints**

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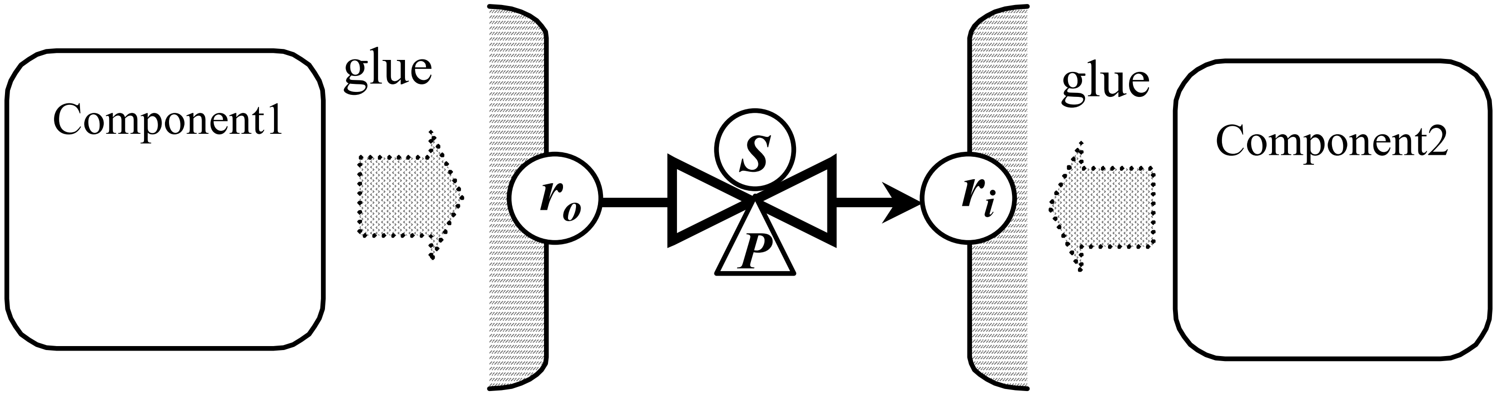
Conceptual Model

Compositional patterns provide a set of rules that govern the interactions among components with localized constraints



Characterized as the interactions between two interactive roles via the architectural styles while complying with the communicatory protocols

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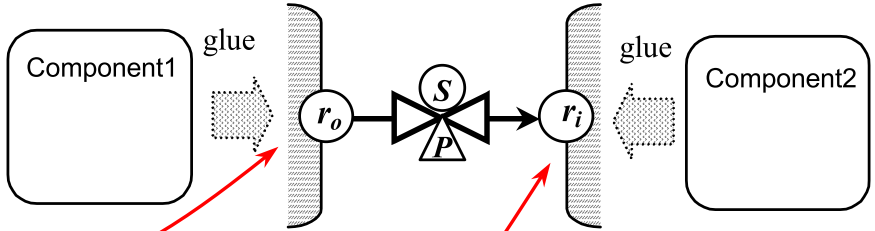
Formal Representation

```
composer Pipeline is generalized
   type Data is private;
   Size : Integer : = 100;
style as  <#pipe-filter#>;
protocol as  <#dataflow-stream#>;
wrapper
 role Outflow is
   port
     procedure Output(d: Data);
     procedure Produce(d: Data) is abstract;
   computation
      Produce (d);
     *[ Output (d) → Produce (d) ◊ met(100) →exception; ]
   end Outflow;
   role Inflow is
   port
     procedure Input(d: Data);
     procedure Consume(d: Data) is abstract;
   computation
     *[ Input (d)→ Consume (d) ◊ mrt(100) →exception; ]
   end Inflow;
collaboration (P : Outflow; C : Inflow)
   P•Produce(d);
  *[ P•Output(d)→ P•Produce(d) □ C•Input(d) → C•Consume (d)]
end Pipeline;
```



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Substantiated Interconnections

Substantiating the interconnections among components deals with following four aspects:

- ***Dependable composers*** **to promote interactions**
- ***Heterogeneous forms*** **to establish communication**
- ***Topological connectivity*** **to guide configuration**
- ***Constraint localization*** **to govern interconnections**

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Topological Connectivity

Topological connectivity simplifies the interconnection among components and comes in the following forms:

- ***Fork (1~N): single producer to multiple consumers***
- ***Merge (N~1): multiple producers to single consumer***
- **Unique (1~1): single producer to single consumer**
- ***Hierarchy: external producer to interact with the internal consumer, and vice versa***

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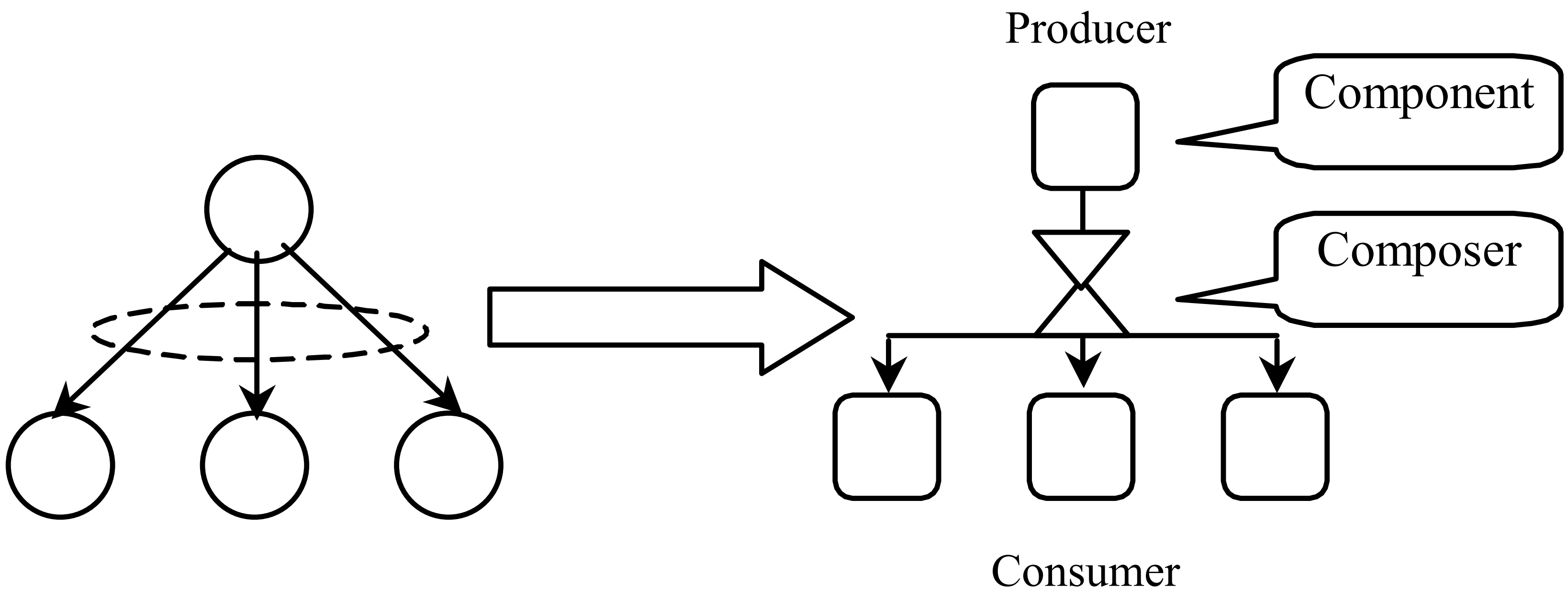
Topological Connectivity -- FORK



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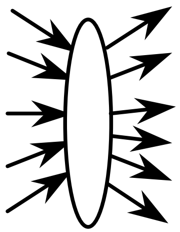
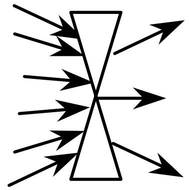
Dependability vs Constraints

This deals with the abstraction of dependability, its translation to quantitative constraints, and the handling of these constraints applied in the design, construction, and evolution of a software-intensive system.

Dependability	Translation	Constraints	Localization	Patterns
• Availability • Reliability • Security • Integrity • Flexibility		• Consistency • Compatibility • Granularity • Heterogeneity • Real time • Synchronization		• Role • Style • Protocol

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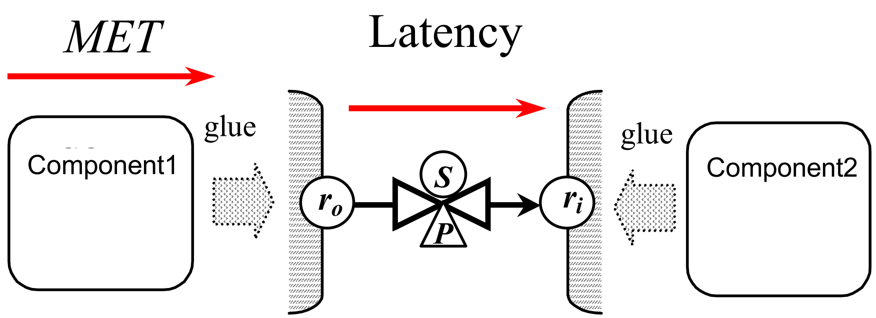
Example of Localized Constraints



Latency: the upper bound of communicating delay
MET : Maximum Execution Time of computation

```
composer Pipeline is generalized
  …
 role Outflow is
 port
   procedure Output(d: Data);
   procedure Produce(d: Data) is abstract;
 computation
       Produce (d);
    *[ Output (d) ◊ latency(60) → Produce (d) ◊ met(100)
     ▯ latency-signaled          → LAT-EXCEPTION
     ▯ met-signaled              → MET-EXCEPTION
     ]
 end Outflow;
   … …
end Pipeline;
```

Dynamical design inspection to monitor system execution

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☞ Conclusion

- **Explicitly defined architectures promise:**
  faster, better, cheaper systems
- **PBA uncovers perspective concerns**
  customer, architect, implementer
- **PBA incorporates requirements validation**
  prototyping / requirement adjustment
- **PBA quantifies invariant architecture**
  heterogeneity, granularity, compatibility

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Thank you very much!

Questions?

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