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Architectural Runtime Configuration Management (WADS ’05)

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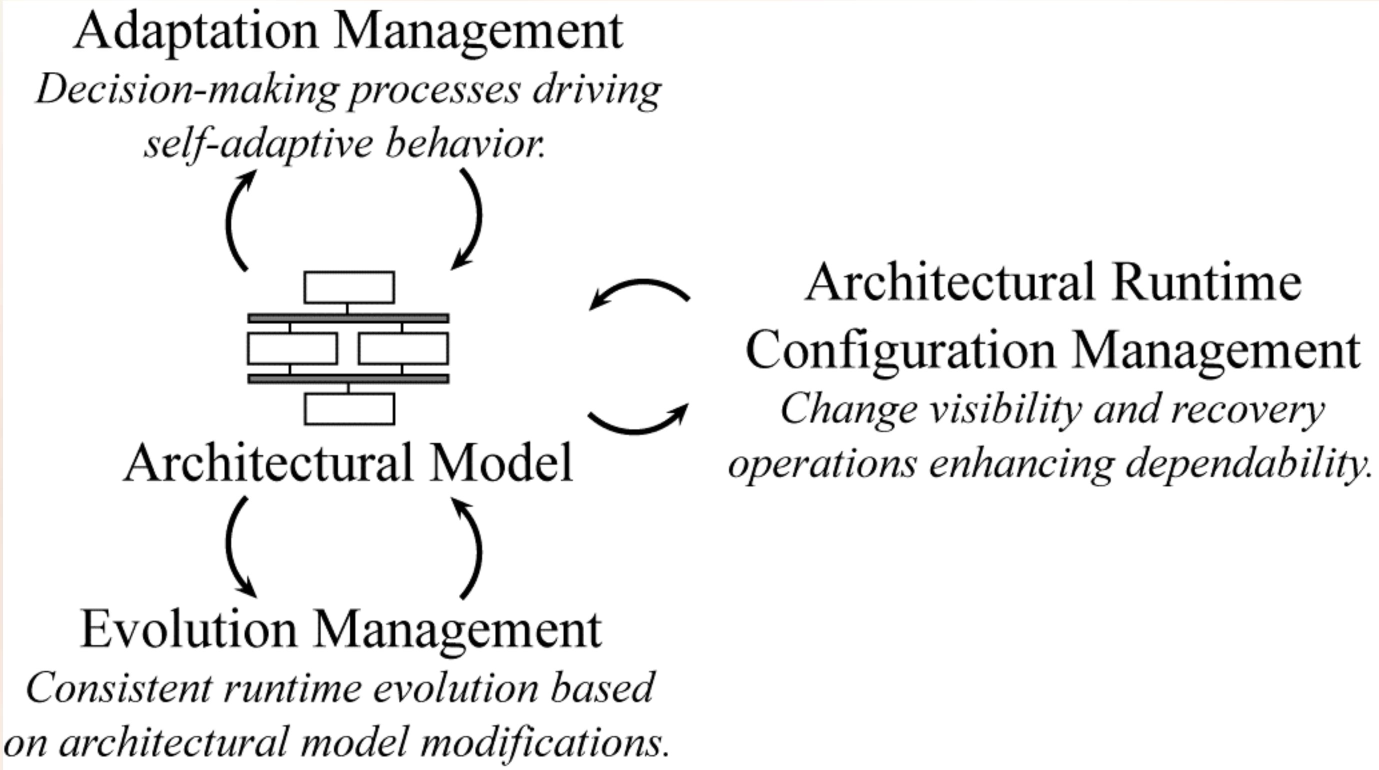
Background: Self-Adaptive Systems

- Systems which autonomously adapt.



Adaptation Management

Decision-making processes driving self-adaptive behavior.

Architectural Model

Architectural Runtime Configuration Management

Change visibility and recovery operations enhancing dependability.

Evolution Management

Consistent runtime evolution based on architectural model modifications.

Background: Fundamental Assumptions

- Explicit architectural models:
  - Evolution and adaptation through these models.
- Out of scope:
  - Decision-making processes guiding adaptations.
  - State restoration and/or transfer.
  - Quiescence before modifications.
  - Architectural invariants throughout adaptation.

Motivation

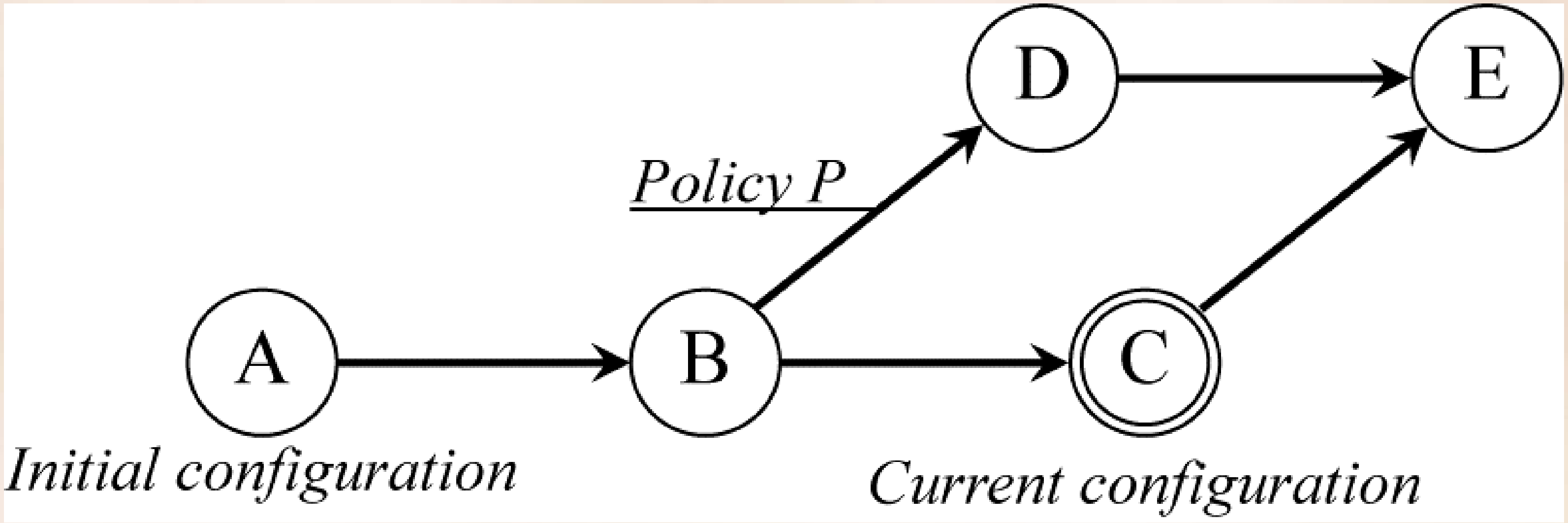
- Low visibility and independent nature of self-adaptive systems *diminish* trust in the adaptation process.
  - Opaque adaptation processes.
  - Behavioral changes only adaptation indicators.
- Dynamic self-adaptive systems can change in unpredictable ways.
  - Dynamic policy-based systems.
- Perceived dependability of the adaptation process.

Approach

- ***Architectural Runtime Configuration Management (ARCM)***
- **Key Features:**
  - Runtime *monitoring* of architecture-based self-adaptive systems.
  - Maintaining a *runtime configuration* version graph.
  - Graphical *visualization* of version information.
  - *Operations* for user-driven fault *recovery*.

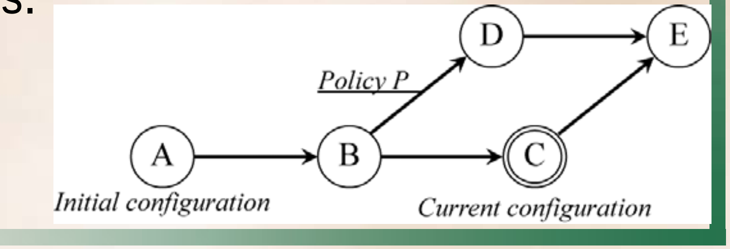
Research Vision: Increasing Visibility

- Configuration version graph indicating adaptations.
  - Cycles, but no loops.
  - Single edge between configurations; anti-parallel.
- Links to policies which cause adaptation.



Research Vision: Increasing Visibility, continued

- Adaptation awareness:
  - Explicit recording of any adaptations in a configuration graph.
  - Generated at runtime, as changes take place.
  - Adaptation history throughout system lifetime.
- Graphical visualization of the configuration graph:
  - Intuitive and easy to understand artifact.
- Enhanced visibility:
  - Reduces the opaque nature of adaptation process.
  - Allows additional questions about systems.
  - Increases trust in the adaptation process.



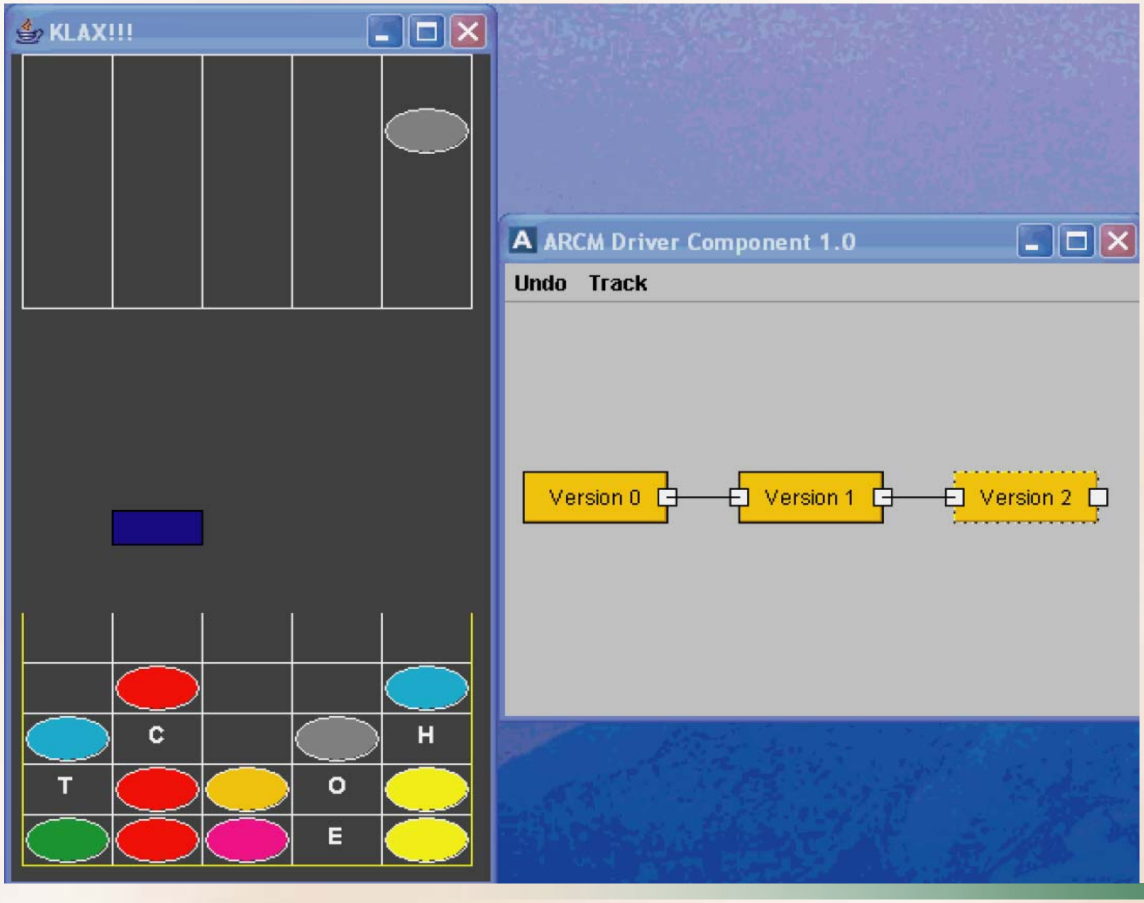
Research Vision: Recovery Operations

- Potentially undesirable adaptations necessitate recovery facilities.
    - Desirability determined by architect.
- Recovery Operations:
    - *Rollforward*
        - Transition in the direction of a graph edge.
    - *Rollback*
        - Transition against the direction of a graph edge.
    - *Out-* and *in-degree* > 1 require user selection.
- These operations provide for user intervention into the self-adaptive process.
    - Leveraging architect expertise.

Prototype Tool Support: *ARCM Driver*

- Integrated into the ArchStudio development environment.
- Observes and monitors systems for runtime adaptations.
- Builds configuration version graph:
  - Records pre- and post-adaptation configuration.
  - Stores bi-directional *diff* files.
- Provides graphical visualization of the version graph.
- Recovery operations:
  - Merges graph's *diff* information for operation enactment.
    - *Diffing* and merging facilities already present.
    - System architecture is evolved by AEM.

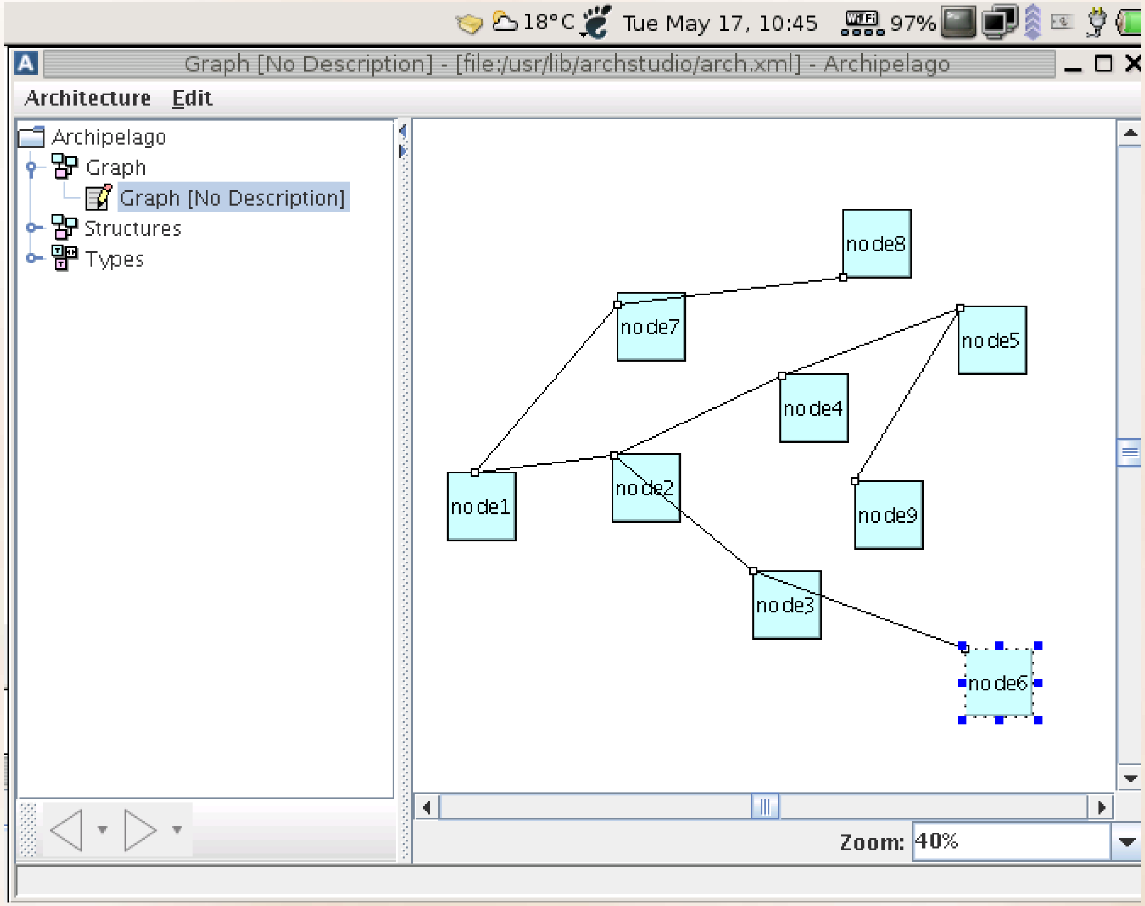
Prototype Tool Support: *ARCM Driver* Screen Capture



Prototype Tool Support: Under Development

- Refined implementation:
  - Transition to xADL schema for graph data (XML-based).
  - Enhanced graphs with support for multiple branching.
  - Identification of duplicate nodes.
    - Architectural configuration hashing.
  - Arbitrary graph transitions.
    - Allows for multi-step recovery operations.
    - *Diff* composition.
- Better visualizations:
  - Integration with Archipelago, the ArchStudio visual editor.
  - Graph layout with DOT.

Prototype Tool Support: Just in...



Future Research Directions

- Further graph annotations:
  - Rejected configurations with counts.
  - Time spent in each configuration.
- Explore automated detection of desirability.
  - Architectural configuration patterns.
- Closer integration with adaptation process:
  - Use recovery operations as an active reflection layer.
  - Include recovery operations into adaptation management decision-making for automated invocation.
  - Leverage graph information in decision-making processes.

Conclusion

- *ARCM:*
  - Maintains a record of adaptation history.
  - Enhances the visibility of adaptations.
  - Provides user-driven fault-recovery facilities.
- Increases in perceived dependability through increased visibility and transparency of the adaptation process.
- Fully decoupled from specific adaptation management and enactment methods.
- Under active development; a new, fully-featured version is expected to be released soon.