Framework for Dynamic and Automatic Connectivity in Hierarchical Component Environments

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Fractal in Nokia Research Center

- From product point of view, Nokia is committed to OSGi
- OSGi component model has very strong relationships with Fractal – not by chance.
- OSGi component model is not hierarchical
- Fractal is used for research purposes in NRC

Motivation

- Context-aware middleware feeds context events into the system
- Handling these events with monolithic middleware yields very complex software. More if-s with each new context event handled. This yields tangled code and large footprint
- Reflective middleware is the solution – application and middleware architecture changes
- Dominant approach: dynamic component-based system. Dynamic: component lifecycle and binding changes during the execution of the program
- How do context events translate to architecture changes?
- Dominant approach: event-condition-action pattern and dedicated reconfiguration managers (components which incorporate reconfiguration logic)
- In hierarchical setting: hierarchical reconfiguration managers, one for each domain.

Dynacomp approach

- No application-specific reconfiguration manager. There is one general reconfiguration manager per domain (domain=composite component) which connects components according to meta-information exposed by the components
- Meta-information is also used to move the components among domains
- There are meta-information-based related works. OSGi R4 and Georgiadis [11] both uses meta-information to automatically connect components.
- None of these work in hierarchical environments and there is the question of the right set of meta-information
- Hierarchical arrangement is important
  - Because it decreases number of connections therefore reconnection time
  - Because it allows reconnection of entire component networks as single component (e.g. moving data synchronization components as one group)

Dynacomp elements

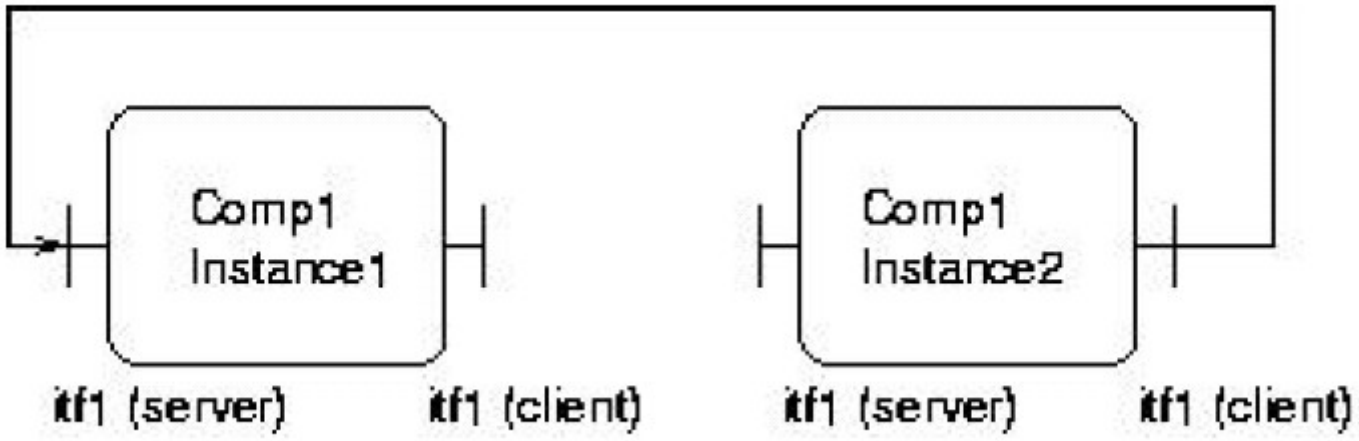
- Dynacomp component types
  - Primitive components: expose meta-information
  - Composite components: arrange components in their domains, move components into and out of the domain according to meta-information
- Meta-information in Dynacomp. Builds on Fractal meta-information but extends it.
  - Interface name.
    - Comes directly from Fractal
  - Interface multiplicity (taken from Service Binder)
    - one, one or more, zero or one, zero or more
  - Priority
    - To resolve ambiguities, the interface pair with the highest sum of priorities will be connected

Meta-information: component and properties

- Properties: way to control component connections. Property is a key-value pair
- Dynacomp assigns primarily properties to components
- It is possible to override component properties with interface properties. These properties are matched only if that particular interface is connected.
- Property language
  - Difficult complexity/efficiency trade-off! The more complex the filter expression is, the more time reconfiguration takes!
  - Service Binder: LDAP Filter
  - Dynacomp:
    - Required property: the component/interface to connect must have that property with the given value in order for the connection to be made.
    - Optional property: if the component/interface to connect has this property, the value must have the given value in order for the connection to be made
    - Forbidden property: the component/interface to connect is not allowed to have this property with this value
  - Optional property cannot be expressed with OSGi R4 LDAP filters

Meta-information: Interface direction

- Interface direction.
  - Beside input and output ports, Dynacomp defines bidirectional ports.
  - Statement to express: certain component instances of same type have to be connected with each other
  - In Dynacomp, this is expressed as a pair of client/server interfaces that are connected in random direction.



Meta-information

- Superproperties: properties that control which domain the component can be placed into. Superproperties of the component are matched against the properties of the composite component
- Export and import list: list of interfaces that can be exported from and imported into this domain
- Timeout: unconnected components “expire” after a timeout
- Creation time: timestamp when the component was created
- Creation lists: lists containing component names and labels. These are reconnection scenarios for certain situations (e.g. if certain even occurs, start creating components from label “event1”)

Reconnection algorithm in short

- Connect the domain according to constraints
- Put every unconnected component into the storage of the domain
- Propagate the storage downward, into the composite components in this domain, considering superproperties and import lists
- Start the components in this domain in dependency order. If any component becomes unresolved during the starting phase, reconnection restarts (a component may delete itself during start)
- Check for timeout and delete components that are in the storage for too long time
- Propagate the storage upward, to the parent of this component considering export list of this domain and reconnect the parent

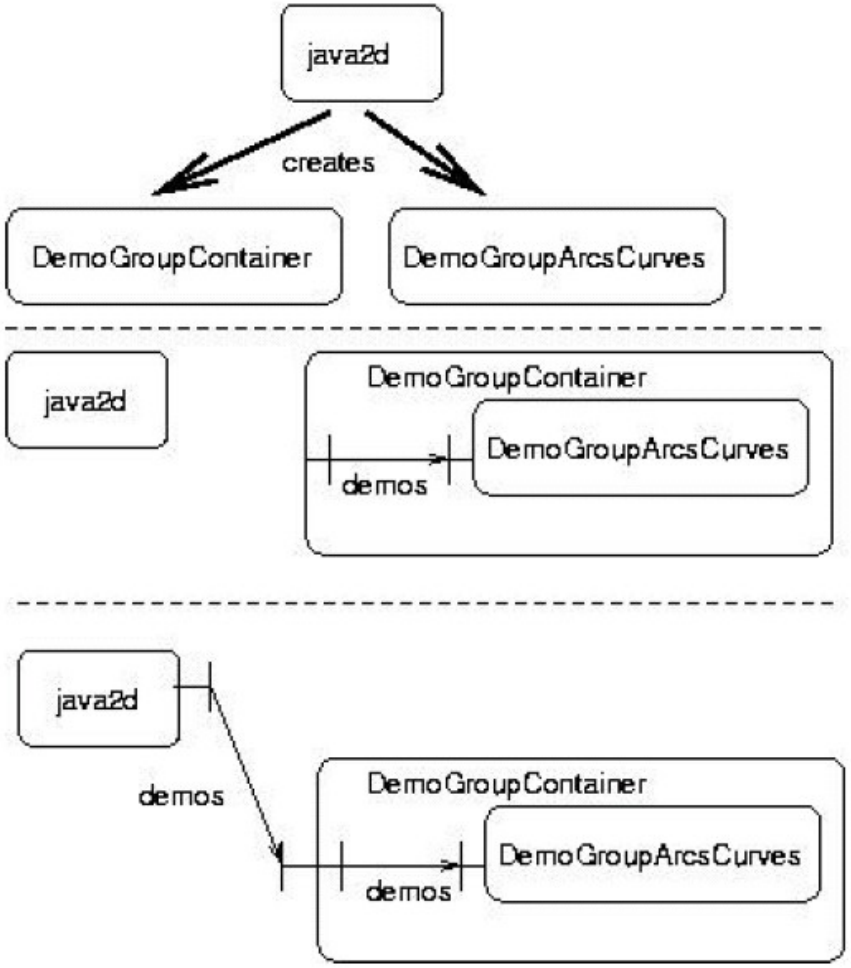
- This algorithm may create endless loops!

Case study: Java2D

- Standard demo shipped with every JDK
- Monolithic application
- Idea: save footprint by componentizing it and activate only the features required by the end user
- Use this mobile-inspired use case to demonstrate Dynacomp
- We will oversee several implemented scenarios

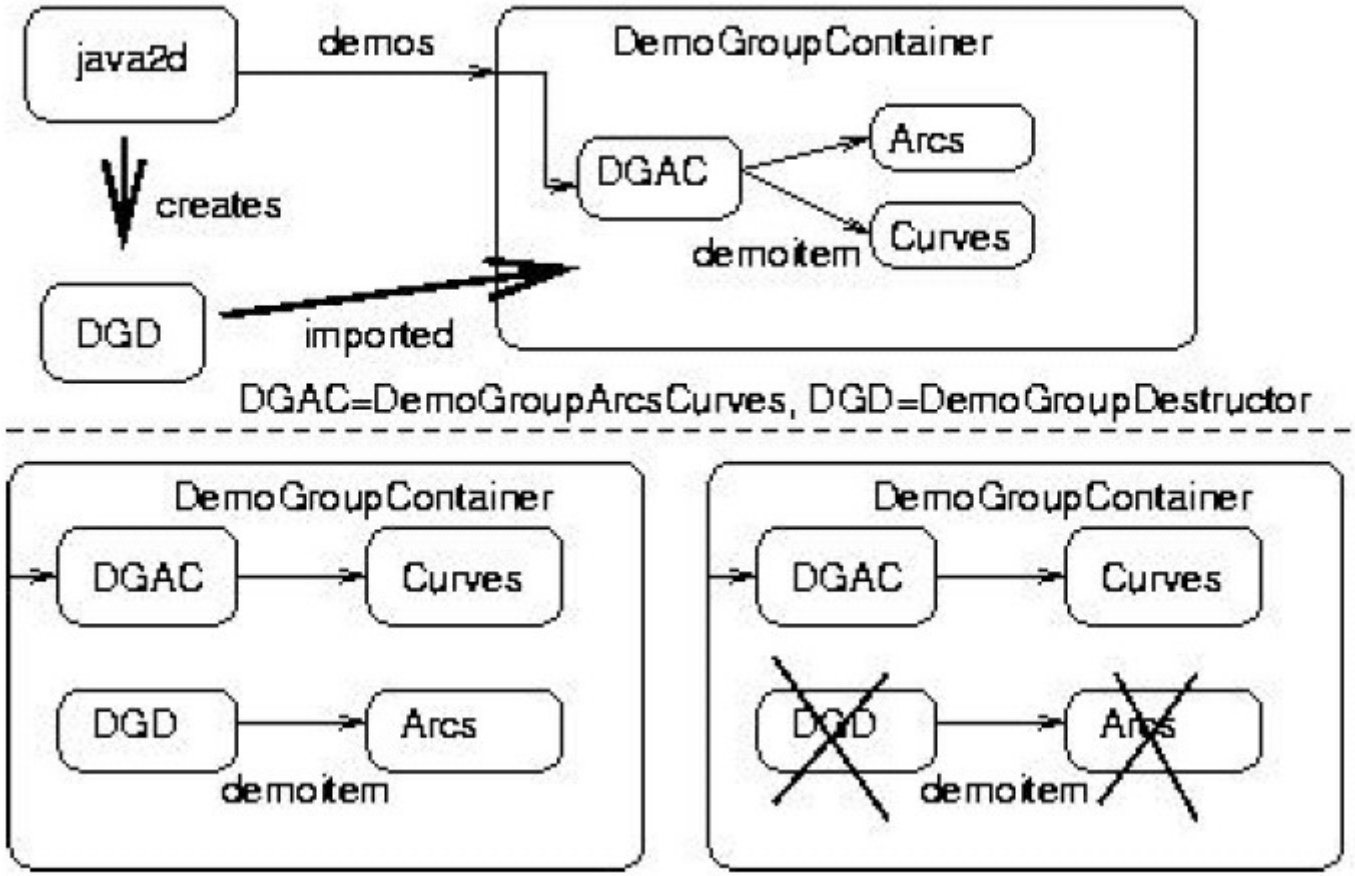
Adding demo groups

- Java2D has demo groups and demos are put into demo groups. One demo group is one tab on the selection panel.



Deleting a demo

- Destructor component is created which searches and destroys the particular demo. Searching is controlled by properties of the destructor and the demo components



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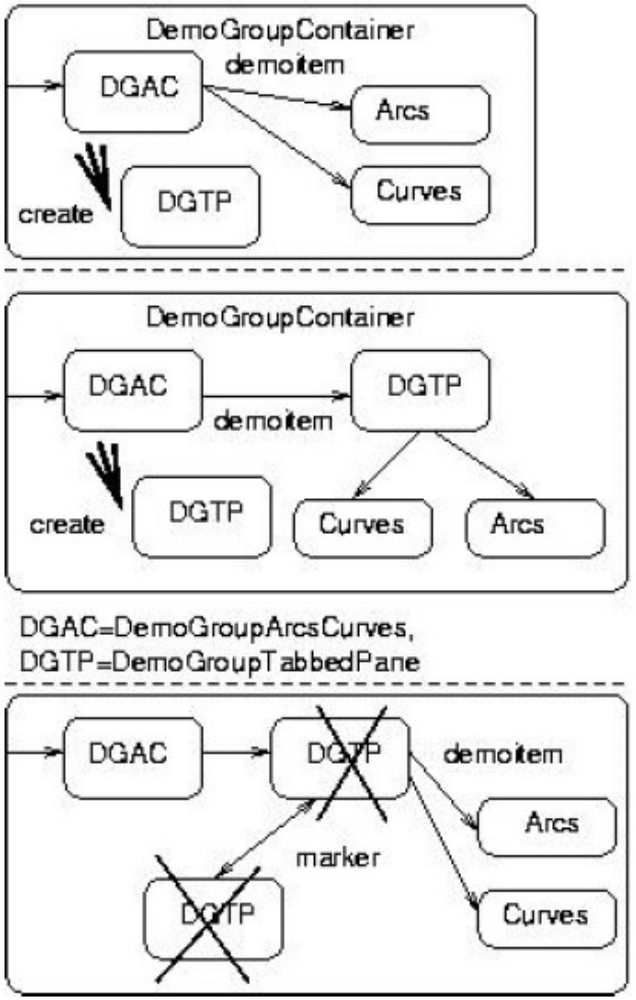
Switching between grid and tabbed pane

- Demos can be rendered by the demo group as tabbed pane or grid. This is implemented by adding a tabbed pane component to the component network. If this component recognizes that there's already another tabbed pane component in the domain, it destructs both therefore restoring grid view.



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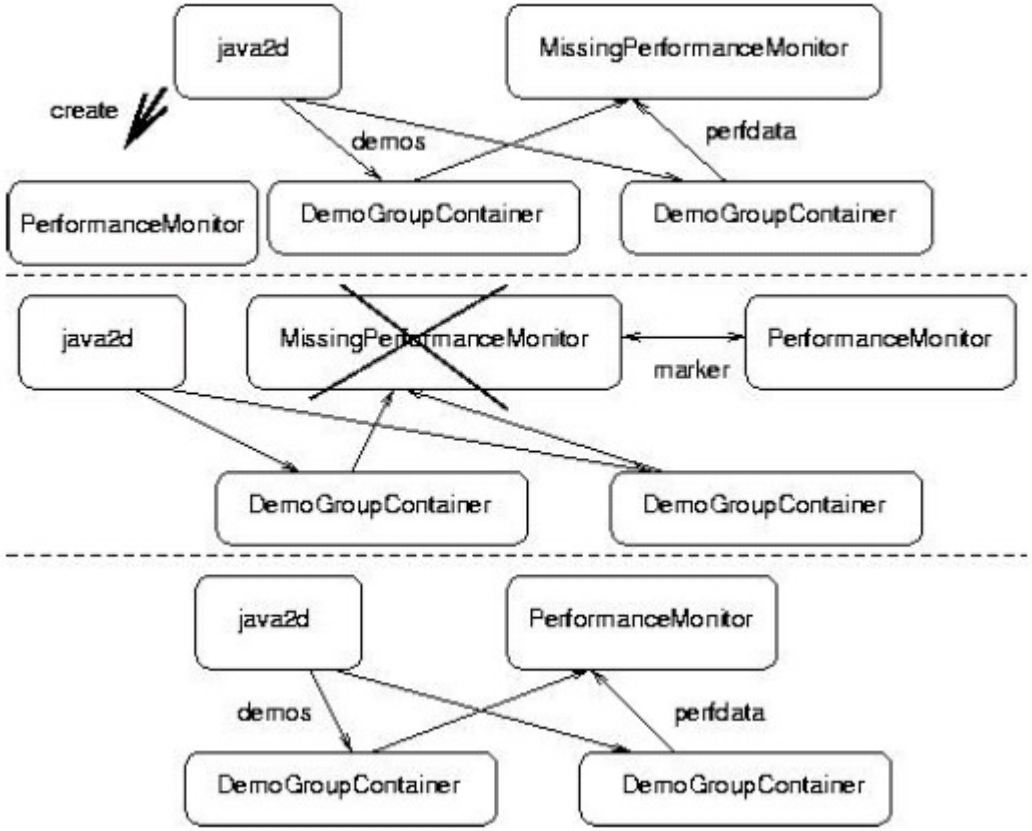
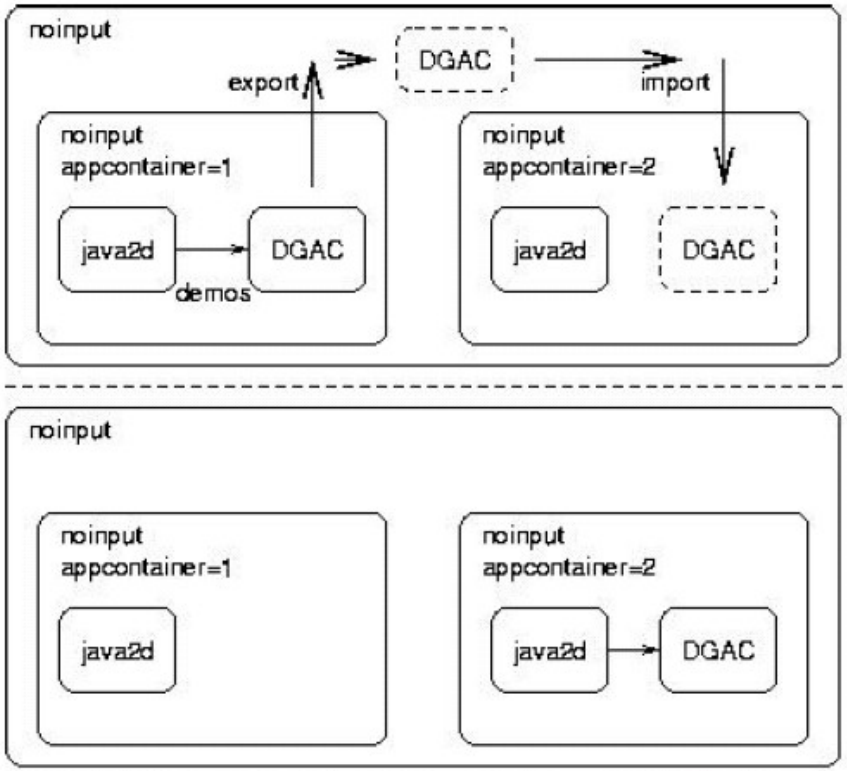
Adding performance monitor

- Performance monitor can be selectively switched on and off. This is accomplished by switching between the dummy and real component.



Moving demo groups between demo frames

- New feature: whole demo groups can be placed to secondary frame



DGAC=DemoGroupArcsCurves (more exactly DemoGroupContainer containing the components belonging to the Arcs&Curves demo group)

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Implementation and results

- Download the stuff: http://javasite.bme.hu/~paller/common/dynacomp.tar.gz
- Static footprint (class file size):
  - Java2D's original version: 387964 bytes
  - Dynacomp version: 376769 bytes.
  - Dynacomp framework (including Fractal API and Julia) is 458825 bytes (397729 bytes from Fractal API+Julia and 61096 bytes from the dynamic reconnection facility)
  - With the framework added, Dynacomp version is larger but the framework can be shared by multiple applications

Dynamic footprint

- Orig: original Java2D
- DC: Dynacomp version with only the particular feature activated
- DCAll: Dynacomp version with all the features activated but the particular feature selected

Demo	Orig (kB)	DC (kB)	DCall (kB)
Arcs&Curves	6135	3675	7305
Clipping	6081	4130	7302
Colors	6339	3904	7617
Composite	6309	4149	7854

Blackout

- Time needed to reconfigure the component framework
- During this time, the application is not accessible

Activity	Time (msec)
Inserting an empty demo group as first demo group	361
Inserting a demo into an empty demo group	736
Inserting a demo as the 4th demo in the group	471
Inserting 4 demo groups with a total of 16 demos	6007
Switching from grid to tabbed view	418
Switching from tabbed to grid view	497

Conclusions

- Dynamic adaptation surfaces in many areas: autonomous systems, self-healing, reflective middleware
- Centralized reconfiguration managers are hard to analyze and extend: each new context element to support adds complexity to potentially all the reconfiguration managers. This paper proposed a more distributed approach where general reconfiguration manager does the reconnection based on meta-information.
- Large component networks need hierarchical component system to minimize reconnection time: this is not supported by OSGi R4
- Blackout effect exists during dynamic reconfiguration
- With appropriate framework, dynamic footprint can be significantly decreased
- Julia's static footprint is large