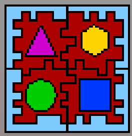

Software Component Engineering

LISHA/UFSC

Prof. Dr. Antônio Augusto Fröhlich

guto@lisha.ufsc.br

http://www.lisha.ufsc.br/~guto

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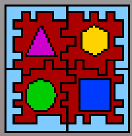
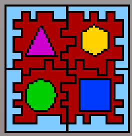


Family-Based Design

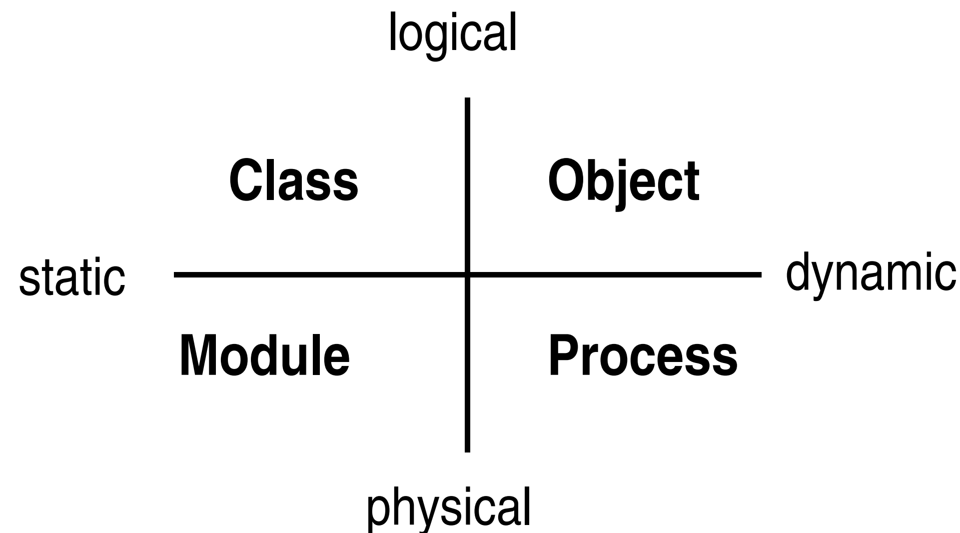
- Commonality and variability analysis
  - Commonality => families
  - Variability => family members
- Incremental system design
  - Hierarchy in family-based design
- Family-oriented abstraction, specification, and translation
  - Application-oriented languages (AOL) to hide commonalities as design secrets

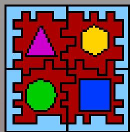


Software Component Engineering

Object-Oriented Design

- Domain analysis and decomposition
  - Objects abstract domain entities
  - Commonality => classes
  - Variability => class hierarchies (subclassing)
- Models

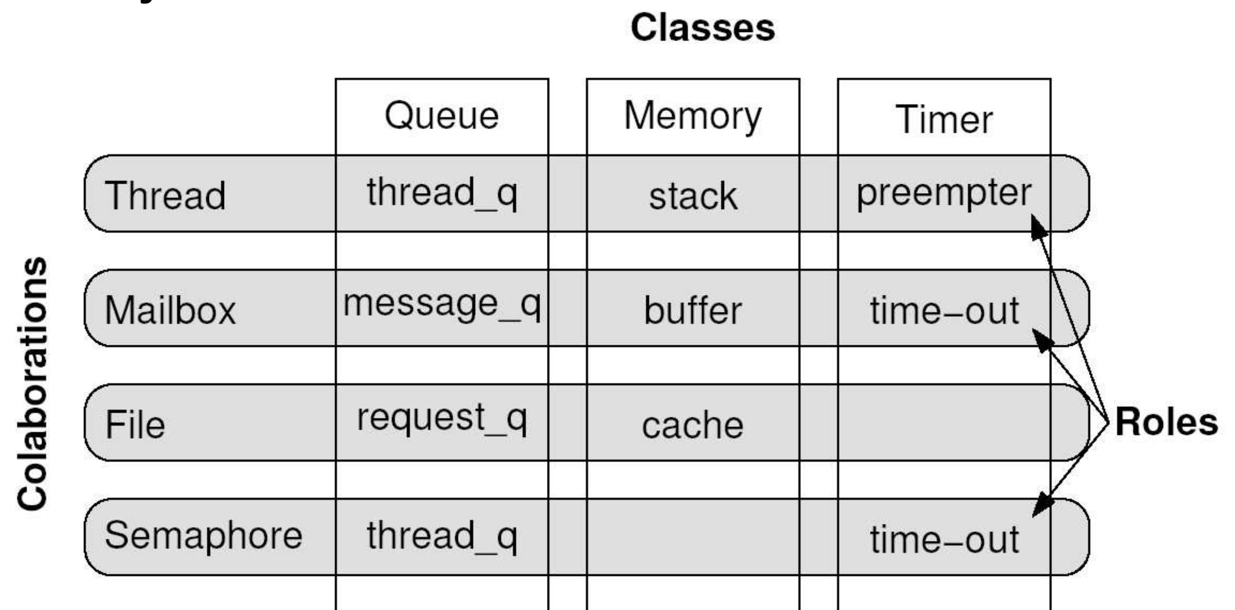


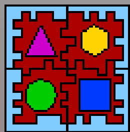


Software Component Engineering

Collaboration-Based Design

- Extends object-oriented design
  - An object can play different roles in a system
  - A cooperating suite of roles (collaboration) can be a better unit of reuse than a class
- Collaboration-based system
  - Composition of independently definable collaborations

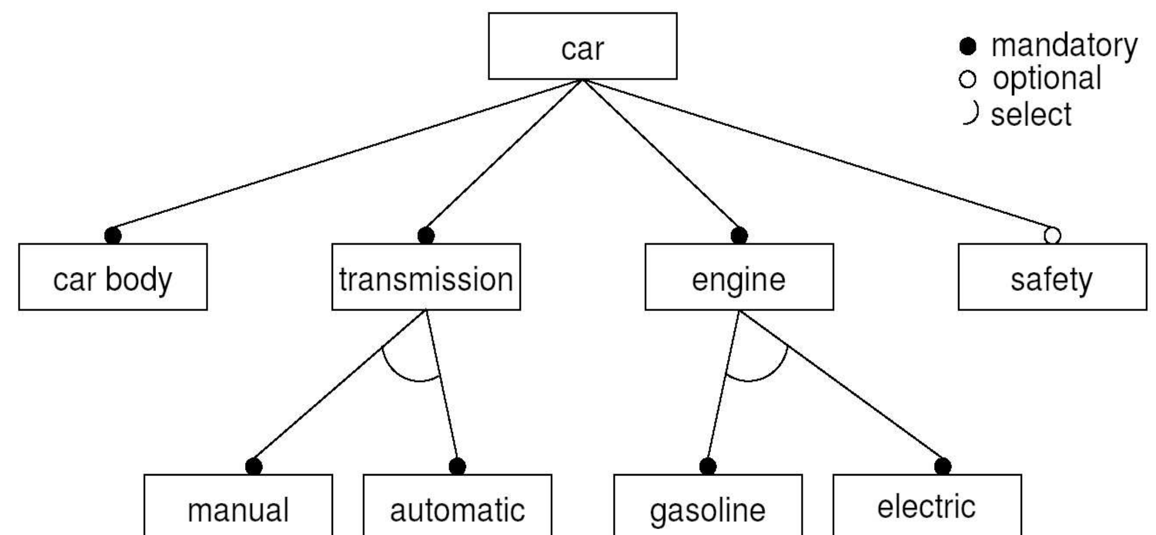


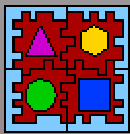


Software Component Engineering

Feature-Based Modeling

- Features enable the design process to be approached from varying levels of detail
  - Sub-features provide a method for viewing features as an aggregation of several, more primitive features
- Natural to use
  - Structures, behaviors, and names are recognizable by designers
- Feature-Oriented Domain Analysis (FODA)

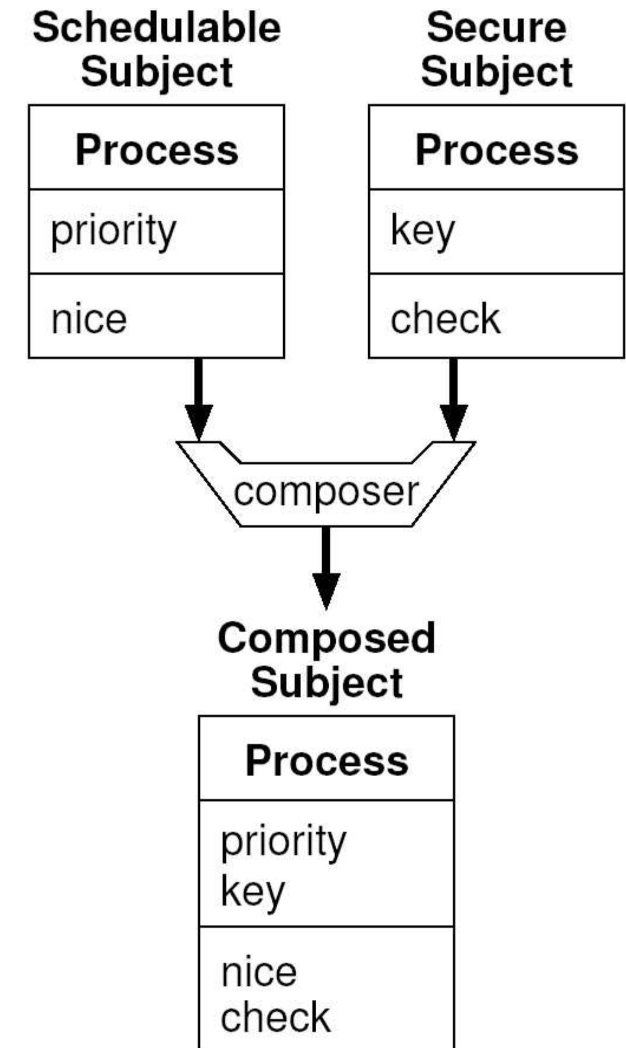


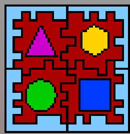


Software Component Engineering

Subject-Oriented Programming

- Extends object-orientation to handle a multiplicity of subjective views of objects been modeled
  - Some properties of an object can be more interesting to some programs than to others
- Subjects: model subjective view of domain
- Subject composition: reconcile subjective views

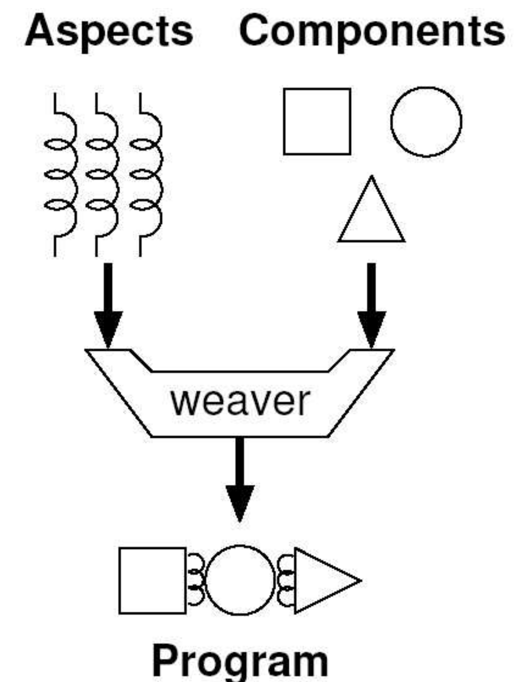


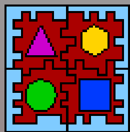


Software Component Engineering

Aspect-Oriented Programming

- Deals with non-functional properties of component-based systems
  - Replace code fragments scattered over several components with reusable aspects
- Aspects
  - Specified in aspect-oriented languages
  - Woven with components





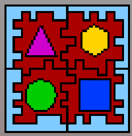
Software Component Engineering

Aspect-Oriented Programming Example

```
aspect Action
{
  advice execution("% A::%(...)") : around() {
    cout << "before exec " << JoinPoint::signature();
    cout << "[that=" << (void *)tjp->that() << ",";
    cout << "target=" << (void *)tjp->target() << "]\n";
    tjp->proceed();
    cout << "after exec " << JoinPoint::signature() << "\n";
  }
  advice call("% A::%(...)") : around() {
    cout << "before call " << JoinPoint::signature();
    cout << "[that=" << (void *)tjp->that() << ",";
    cout << "target=" << (void *)tjp->target() << "]\n";
    tjp->proceed();
    cout << "after call " << JoinPoint::signature() << "\n";
  }
};
```

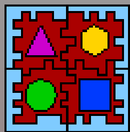
OUTPUT:

```
before call int A::a(int,float) [that=(nil), target=0xbfffed0f]
before exec int A::a(int,float) [that=0xbfffed0f, target=0xbfffed0f]
after exec int A::a(int,float)
after call int A::a(int,float)
```



Generic Programming

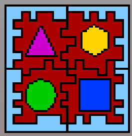
- Reusability by means of parameterization
  - Decouple algorithms from data structures
- Generic components
  - Externally adjustable (parameters)
  - Compile-time
- C++ Standard Template Library (STL)



Software Component Engineering

Generic Programming Example

```
template <int n_res, class Resource>
class Allocator
{
public:
  Allocator() { for (int i = 0; i < n_res; i++) used[i] = false; }
  Resource* alloc() {
    int i;
    for (i = 0; (i < n_res) && used[i]; i++);
    return (i == n_res) ? 0 : (used[i] = true, &resource[i]);
  }
  void free(Resource * res) {
    int i;
    for (i = 0; (i < n_res) && (&resource[i] != res); i++);
    if (i != n_res) used[i] = false;
  }
private:
  bool used[n_res];
  Resource resource[n_res];
};
```

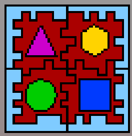


Static Metaprogramming

- Multilevel languages
  - Parts of the input program are evaluated at compile-time
  - Supported by C++
    - Templates, expression evaluation, inlining
- Component transformation and composition

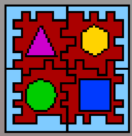
```
template <int n>
struct Factorial { enum { RET = Factorial<n - 1>::RET * n }; };

template <>
struct Factorial<0> { enum { RET = 1 }; };
```



Generative Programming

- Domain engineering
  - Families
- Configuration knowledge
  - Components into product
- Generators
  - Aspect-oriented programming
  - Subject-oriented programming
  - Static metaprogramming



Multiparadigm Design

- A single paradigm cannot cover peculiarities of all domains
  - Paradigms have to be combined
- Example
  - Object-orientation +
  - Family-based +
  - Structured +
  - Logic +
  - ...