Implementing Feature Interactions with Generic Feature Modules

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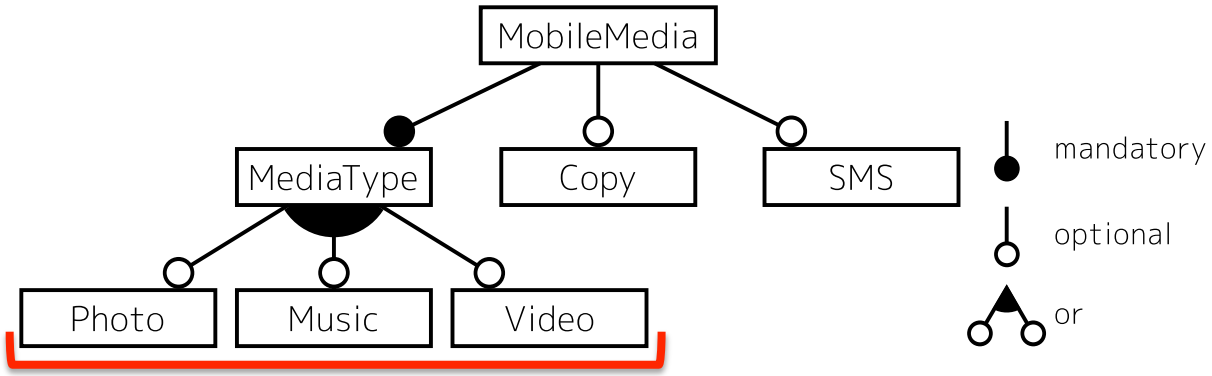
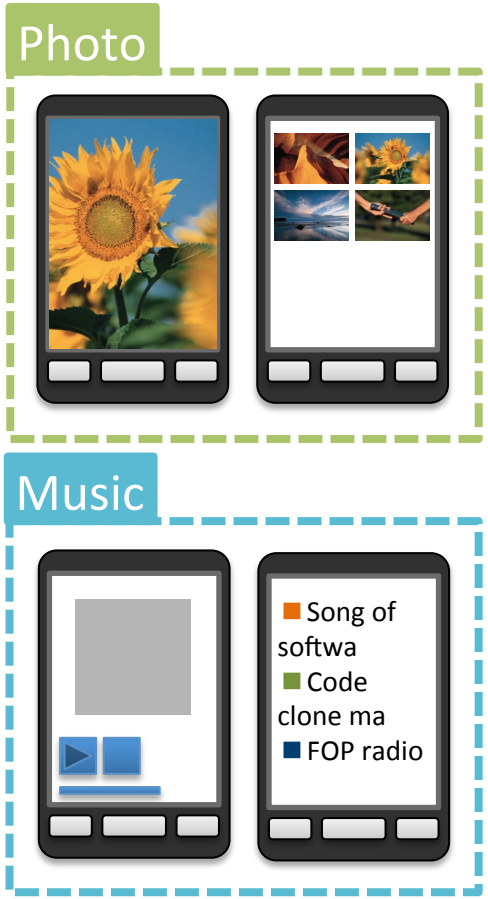
Software product lines and features

- A family of similar software products
- MobileMedia SPL [T. Young, et al., AOSD 2005 demo]
  - A multimedia management application SPL
  - e.g. Only music for character-display devices
- Developed by *selecting* features



or-features: select at least one



How can we implement features?

- Conditional compilation
  - removes unnecessary feature
- Multiple features shares the same file
  - limits development for each feature
  - No encapsulation, etc…

```
class Application {
#ifdef PHOTO
  PhotoListScreen photoListScreen;
  PhotoController photoController;
#endif
#ifdef MUSIC
  MusicListScreen musicListScreen;
  MusicController musicController;
#endif

  public void startApp {
#ifdef PHOTO
    photoListScreen = new PhotoListScreen();
    photoController = new PhotoController();
#endif
#ifdef MUSIC
    musicListScreen = new MusicListScreen();
    musicController = new MusicController();
#endif
  }

  public static void main(String[] args) {
    Application app = new Application();
    app.startApp();
}}
```

Features implementation in AOP

- Many languages allows separating features
  - AspectJ, GluonJ, AHEAD's Jak, (Feature House), …
- The `PhotoInit` reviser [S. Chiba et al., OOPSLA 2009]
  - add fields to `Application` destructively
  - overrides `startApp` method executes it instead of the original

```
class PhotoInit revises Application {
  PhotoListScreen screen;
  PhotoController cont;

  public void startApp() {
    screen = new PhotoListScreen();
    cont = new PhotoController();
    super.startApp();
}}
```

separate

separate

```
class Application {
  … screen;
  … cont;

  public void startApp() {
    screen = …;
    cont = …;
    … other initializations …
}}
```

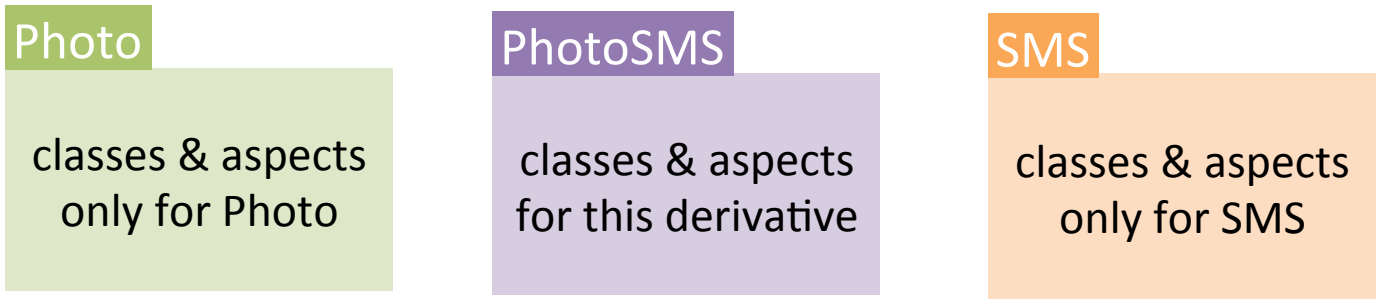
Feature interaction

- Additional behavior for combination of features
  - needed when they are used together in a product
  - cannot be obtained by naively combining the implementations of features
- Show “SMS” on the photo viewer
  - if Photo and SMS features are used

Derivatives

[J. Liu et al., ICSE 2006]

- Implement feature interactions separately
  - A special feature used only when interacting features used
- Classes and aspects for interacting features should not contain code for the interaction
  - Necessary only when all of them are used



The optional feature problem

[J. Liu et al., ICSE 2006]
[C. Kästner et al., SPLC 2009]

- Exponential explosion?
  - $2^n - n - 1$
    - if all combination of features interacts
  - 53 interactions in 38 features [C. Kästner, et al. SPLC 2009]
    - An AspectJ implementation of Berkley DB has
- 6 derivatives between
  - {Photo, Music, Video}, {Copy, SMS}
- Derivatives must be prepared
  - to build products just by selecting features without writing code

	Copy	SMS	…
Photo	PhotoCopy	PhotoSMS	Photo…
Music	MusicCopy	MusicSMS	Music…
Video	VideoCopy	VideoSMS	Video…
…	…Copy	…SMS…	…

Derivatives are often redundant

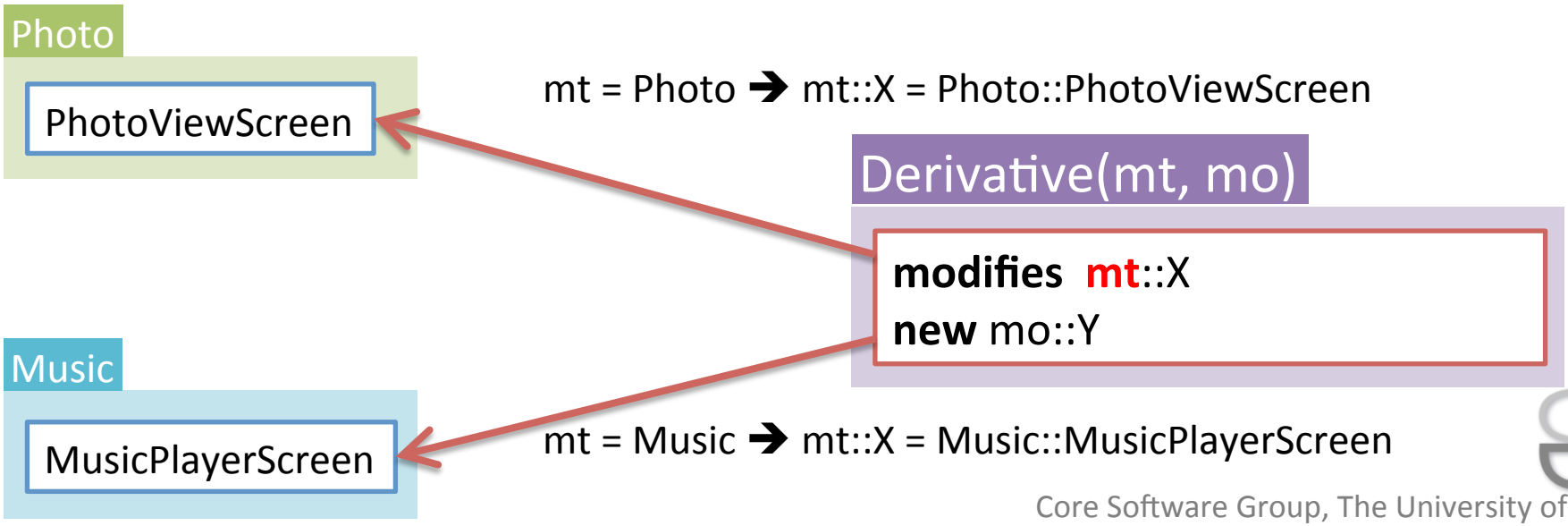
- Found in MobileMedia
  - Only minor difference in class names.
  - So they cannot be merged into one derivative
  - Since derivatives are implemented like normal features

```
class AddSMSToPhoto revises PhotoViewScreen {
  void initForm() {
    t.addCommand(new SMSCommand());
    super.startApp()
}}
```

```
class AddCopyToMusic revises MusicPlayerScreen {
  void initForm() {
    t.addCommand(new CopyCommand());
    super.startApp();
}}
```

Solution: Generic derivatives

- Write a template and generate derivatives for every combination
  - Template parameters are features
  - Automate enumeration of all the combination
- F::C—feature F's class C



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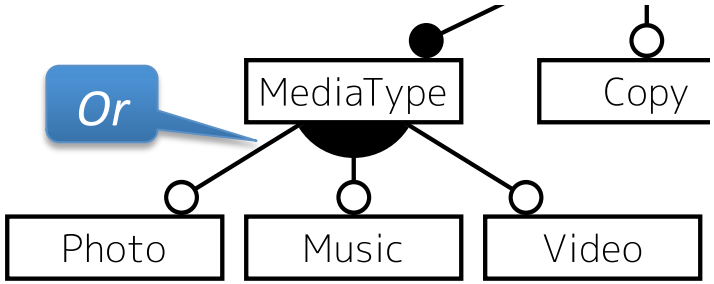
FeatureGluonJ: a new FOP language

FOP: Feature-oriented programming language

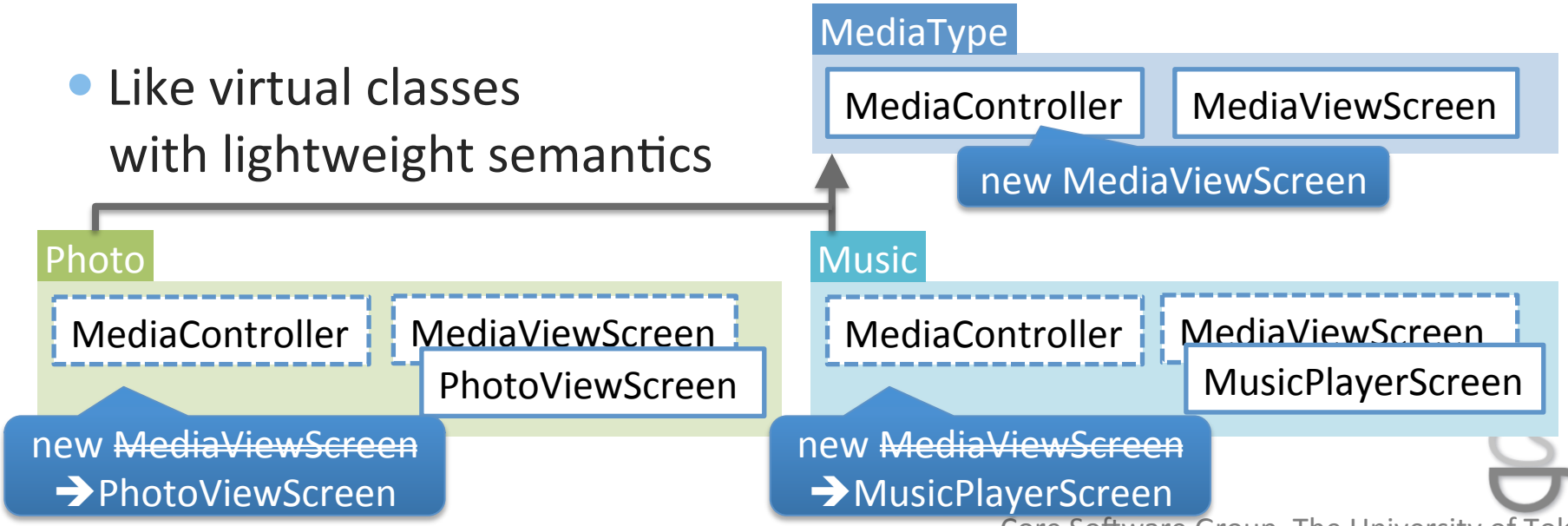
- Interface among feature modules
  - Specifies the classes that a feature module must contain
  - For "type-safe" templates
    when using a feature as a template parameter
- Feature module
  - Contains classes and revisers (aspect)
  - Can inherit from an abstract feature module,
    which works as an interface.
    - Also found in CaesarJ and ObjectTeams



{Photo, Music, Video} is a MediaType

Inheritance for feature modules

- A sub feature module can
  - Use the classes and revisers in the super module
  - Rename a class in the super module
  - Add new classes, methods, and fields.
  - Modify a class in the super module by revisers (or aspects)
  - Like virtual classes with lightweight semantics



Generic derivatives in FeatureGluonJ

- Implement by a template feature module
  - Parameters are feature modules.
- forevery
  - Automatically enumerate every combination of feature modules and Instantiate the template

MediaOpMediaTypeFE

```
feature MediaTypeFileOp defines forevery(mt, mo) {
  abstract import feature mt: MediaType;
  abstract import feature mo: MediaOp;
}
```

```
class AddCmdToView revises mt::MediaViewScreen {
  void initMenu() {
    addCommand(new mo::MediaOpCommand());
    super.initMenu();
}}
```

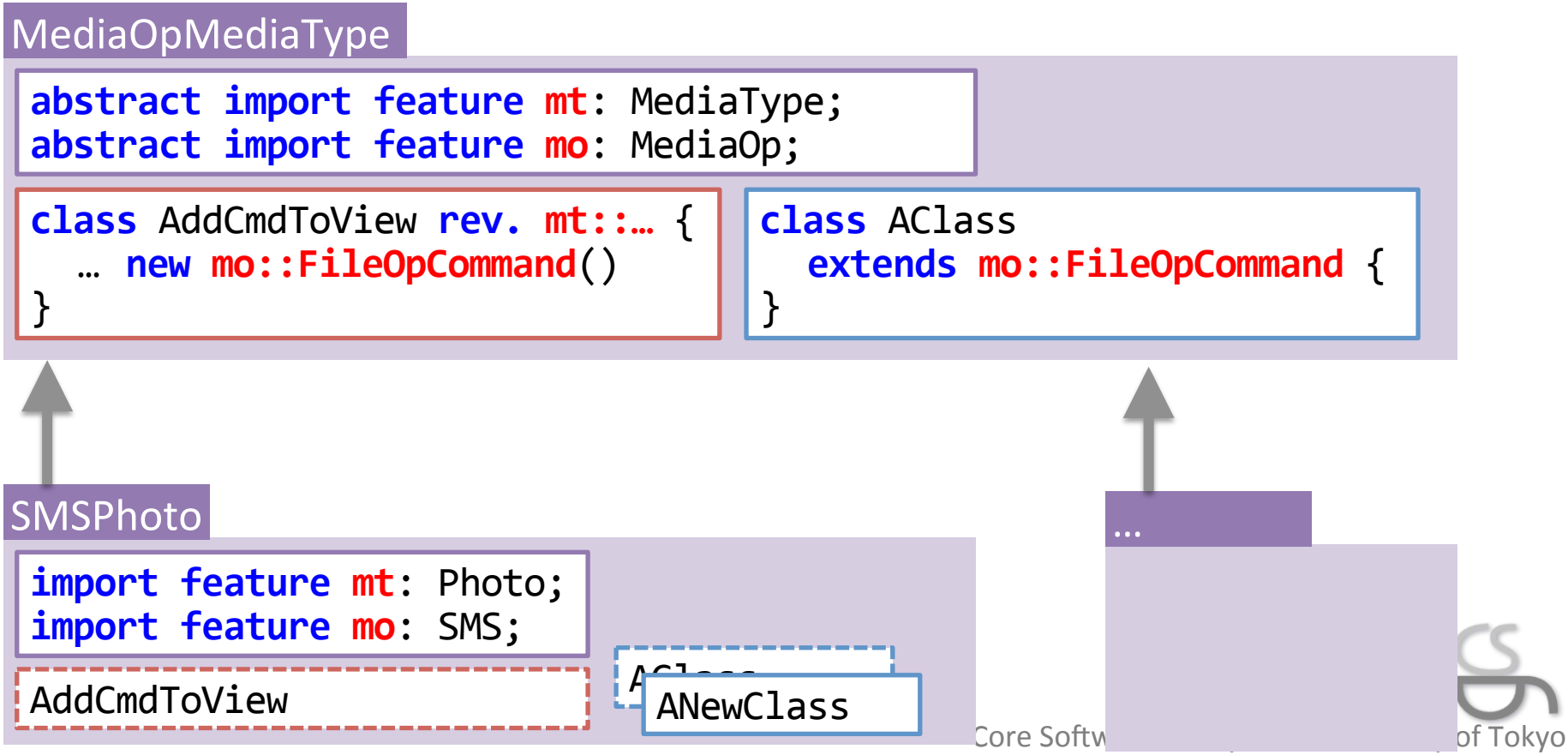
Photo::PhotoViewScreen

Music::MusicPlayerScreen

always provided by mt::MediaViewScreen

Incremental implementation of derivatives

- Can manually instantiate a template (if needed)
  - for customizing the generated feature modules.



Related work

- Languages with virtual aspects + virtual classes
  - CaesarJ, Object Teams
  - designed for reusable collaboration of classes and aspects
    - across product lines
    - require to combine classes (glue code) for each product
  - Object Teams supports dependent team (collaboration) but it can depends on only a team
- Annotation based approach
  - #ifdef–#endif, CIDE
  - How reduce redundancy of code for interaction?
    - especially between or-features

Conclusion

- FeatureGluonJ
  - A generic feature module as a template for derivatives
  - Automatic template instantiation
  - The template instantiation is “type-safe”
    - by introducing a feature interface
- Future work
  - Case study and evaluation
    - few appropriate SPLs (e.g. non OOP)
  - Algebra model, formal definition of semantics
  - Feature local variables, method, …