Software Product Lines

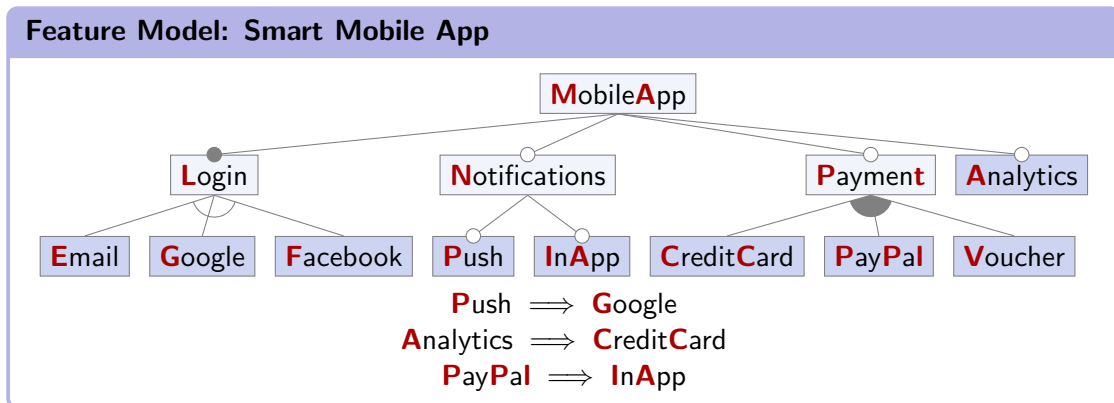## Exercise 4: Feature Modeling

1. **Feature Modeling Fundamentals**
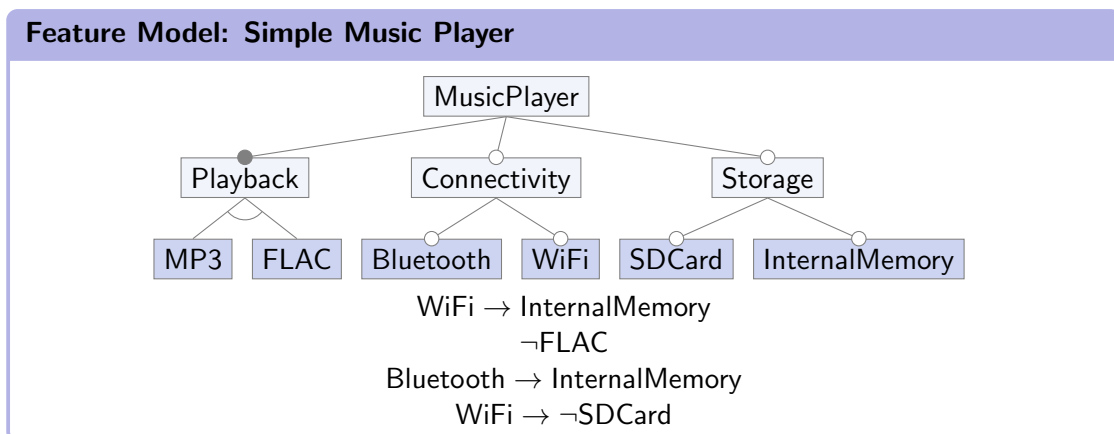
   Consider the following feature model for a mobile app product line. (Abbreviations of the features names are highlighted in red.)

   Feature Model: Smart Mobile App

   (a) What is a feature model, and what are its typical purposes and applications in software product line engineering?

   (b) Explain the given feature model, including its structure and constraints. Provide one valid and one invalid configuration along with the reasoning behind each choice.

2. **Feature Model Analysis**

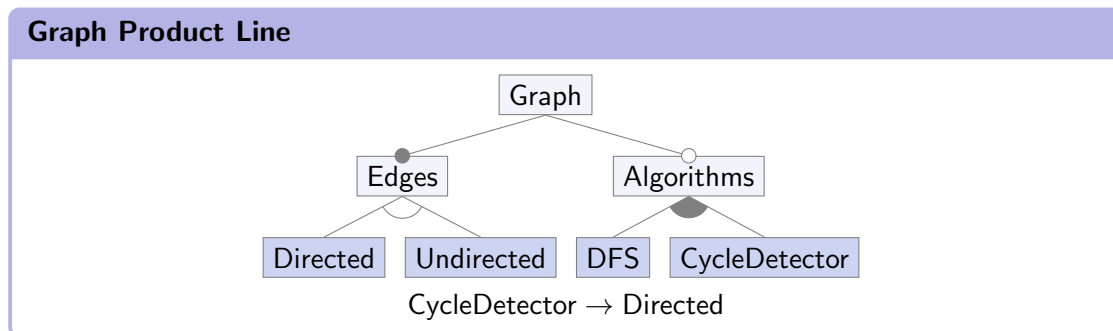   Analyze the following feature model for a simple music player device.

   Feature Model: Simple Music Player

   (a) Is the feature model void? Justify your answer.

   (b) Identify which features are core and which are dead.

   (c) Propose a new constraint that would make Bluetooth a dead feature.

(d) How can a SAT solver be applied to perform the analyses (a) and (b)?

3. **Feature Model Transformation**

   You are given the following feature model.

   Graph Product Line

   Graph
   — Edges
     — Directed
     — Undirected
   — Algorithms
     — DFS
     — CycleDetector

   CycleDetector → Directed

   (a) How many valid products can be derived from the given feature model?

   (b) How can you in general determine the number of configurable products? What is the difficulty?

   (c) Diagrams are not the only language for feature models. Transform the given diagram into a

   - propositional formula,
   - CNF (use the propositional formula you just created),
   - set of all valid configurations (subset of the superset of all features).

   What are the advantages and disadvantages of these notations? Do you know other languages for constraints?

4. **Derive Feature Models from Requirements**

   Often, customers may already have various requirements in mind, but they are not formalized as feature models. In the following scenarios, help the customer to specify their requirements.

   (a) Our first customer wants to build a product line for smart home control devices. They mention the following requirements:

   - Voice control requires a microphone and a speaker.
   - Remote control via smartphone requires Wi-Fi.
   - Displaying a user interface requires a touchscreen.
   - Motion detection requires an infrared sensor.
   - Outdoor installation requires weatherproofing.

   Create a feature model representing these requirements. What dependencies or features would you suggest adding?

   (b) Our second customer wants to build a product line for smartphones. They are unsure about dependencies, but provide examples of their sold models:

   - 5.5 inch Display, Front Camera, Fingerprint Sensor, NFC, Wi-Fi
   - 6.1 inch Display, Front Camera, Back Camera, NFC, Wi-Fi, 5G

- 5.0 inch Display, Front Camera, Fingerprint Sensor, Wi-Fi
- 6.5 inch Display, Back Camera, Wi-Fi, 5G

Create a feature model based on these sample products. What difficulties might arise when creating a feature model from only a small set of example products?

5. **How many sandwiches does Subway sell?**

   (a) Try to calculate (using a method of your choice) the (approximate) number of all sandwiches that can be ordered at Subway. Use the given order form. Explain your idea. Is it manual or machine-supported?

   Can you find a solution? If you have difficulties, document them. How well does your result approximate the actual solution?

   (b) Are there aspects regarding this form you would criticize as a product-line engineer? How do these aspects make finding the right answer more difficult?

SUBWAY Order Form

Contact Person Name:_____   Pick up Time:_____   Page_____of_____

Phone Number:_____   Total # of Sandwiches_____

Name:_____	Name:_____	Name:_____
☐ 6" ☐ 12" ☐ Salad ☐ Kid's Meal ☐ Toasted ☐ Flatbread ☐ English Muffin ☐ Meal Check size 1 Side & 1 Drink	☐ 6" ☐ 12" ☐ Salad ☐ Kid's Meal ☐ Toasted ☐ Flatbread ☐ English Muffin ☐ Meal Check size 1 Side & 1 Drink	☐ 6" ☐ 12" ☐ Salad ☐ Kid's Meal ☐ Toasted ☐ Flatbread ☐ English Muffin ☐ Meal Check size 1 Side & 1 Drink
☐Italian ☐9 Grain Wheat ☐9 Grain Honey Oat ☐Italian Herbs & Cheese	☐Italian ☐9 Grain Wheat ☐9 Grain Honey Oat ☐Italian Herbs & Cheese	☐Italian ☐9 Grain Wheat ☐9 Grain Honey Oat ☐Italian Herbs & Cheese

Column 1:

All Day Sandwiches
- ☐ B.L.T.
- ☐ Big Philly Cheesesteak*
- ☐ Ham
- ☐ Buffalo Chicken*
- ☐ Chicken & Bacon Ranch Melt
- ☐ Cold Cut Combo
- ☐ Egg & Cheese*
- ☐ Egg Salad**
- ☐ Italian B.M.T.®
- ☐ Meatball Marinara
- ☐ Oven Roasted Chicken
- ☐ Roast Beef
- ☐ SO Chicken Teriyaki
- ☐ Spicy Italian
- ☐ Steak & Cheese
- ☐ Subway Club®
- ☐ Subway Melt®
- ☐ Tuna
- ☐ Turkey Breast
- ☐ Turkey Breast & Ham
- ☐ Veggie Delite®

Breakfast Sandwiches
- ☐ Ham, Egg & Cheese   White or Yellow
- ☐ Bacon, Egg & Cheese   White or Yellow
- ☐ Breakfast B.M.T.® Melt   White or Yellow
- ☐ Steak, Egg & Cheese   White or Yellow
- ☐ Sunrise Subway Melt®   White or Yellow
- ☐ Egg & Cheese   White or Yellow

☐American*/Processed Ched.** ☐Monterey Ched. ☐ Other_____
☐Bacon ☐ Double Meat ☐ Pepperoni ☐ Extra Cheese
☐ Lettuce ☐ Spinach* ☐ Tomatoes ☐ Cucumbers ☐ Gr. Peppers
☐ Onions **Upon Request:** ☐ Pickles ☐Olive ☐Jalapeños* ☐B.Peppers

SAUCE: ☐ Honey Mustard ☐ Chipotle Southwest ☐ Sweet Onion
☐Mayonnaise ☐Light Mayonnaise ☐Ranch ☐ Mustard ☐ Y or ☐ B
☐Oil* ☐ Red Wine Vinegar* ☐House Sandwich Sauce** Other_____

DRINK
☐ 16oz.** ☐ 21oz. ☐ 30oz.* ☐ Bottled ☐Coffee ☐Other:_____
Flavor:_____ Quantity_____ Size_____
SIDES
☐ Chips ☐Cookies ☐ Apples ☐ Yogurt ☐Soup ☐ Other:_____
Flavor:_____ Quantity_____
*US ONLY
** CANADA ONLY

(Columns 2 and 3 repeat the identical layout as Column 1.)

Additional Instructions:_____
_____
_____