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Software Engineering and Architecture

Multi Dimensional Variance

Ultra flexible software

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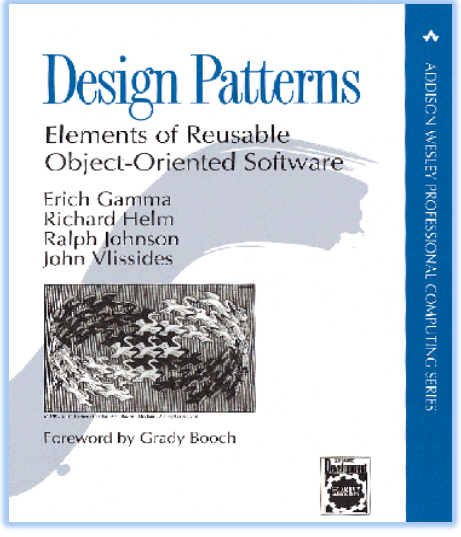
Goal and means to an end?

- Patterns:
  - *Goal in itself or just the means to an end?*

- Patterns are interesting as *means* to achieve some specific quality in our software:
  - elements of **Reusable** ...

- A key aspect is handling **variance**



Variance

- Factoring out in roles and delegating to objects that play roles is a very strong technique to handle **multiple dimensions of variance!**
  - that is – a piece of software that must handle different types of context
    - work on both MariaDB and MongoDB database
    - work in both testing and production environment
    - work both with real hardware attached or simulated environment
    - work with variations for four different customers
- *Here all types of combinations are viable !*

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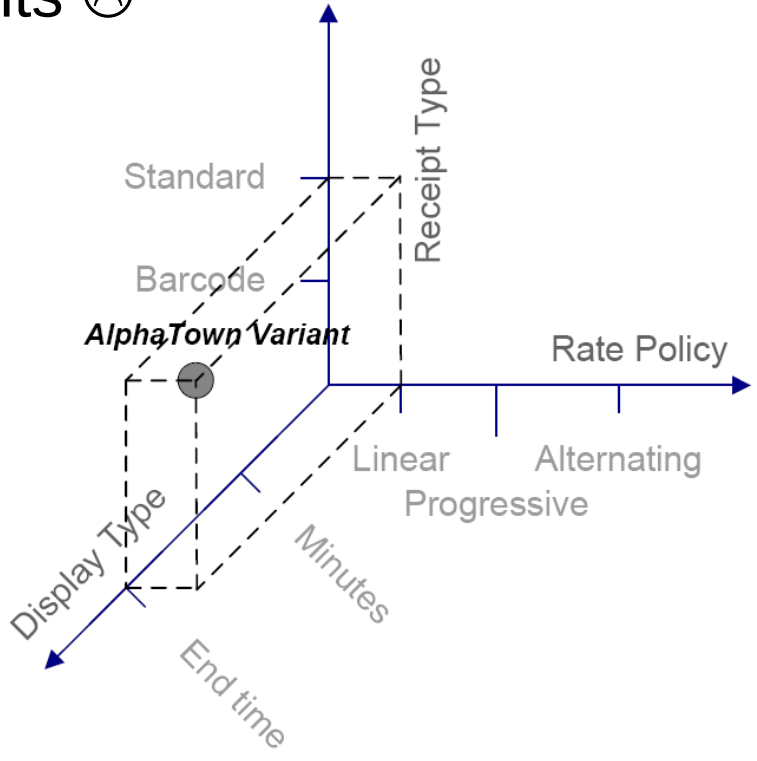
New Requirements

- Alphatown county wants the display to show *parking end time* instead of minutes bought!
  - I.e “Parking ends at 15:47”

Combinatorial explosion!

- All these requirements pose a *combinatorial explosion* of variants ☹



There are 3*2*2 = 12 combinations. This may be doubled if we include overriding weekend day algorithm !

Restating the Options

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Parametric Variance

- Variant handling by **if (param**) or **#ifdef's** is well known, but the code simply bloats with conditional statements.

- Example: GNU C compiler has a single statement that includes 41 macro expansions !!!
- I wonder what that code does???

- #ifdef (MSDOS && ORACLE || MYSQL && …)
- #ifdef (DEBUG)
  - quickly you loose control of what is going on…

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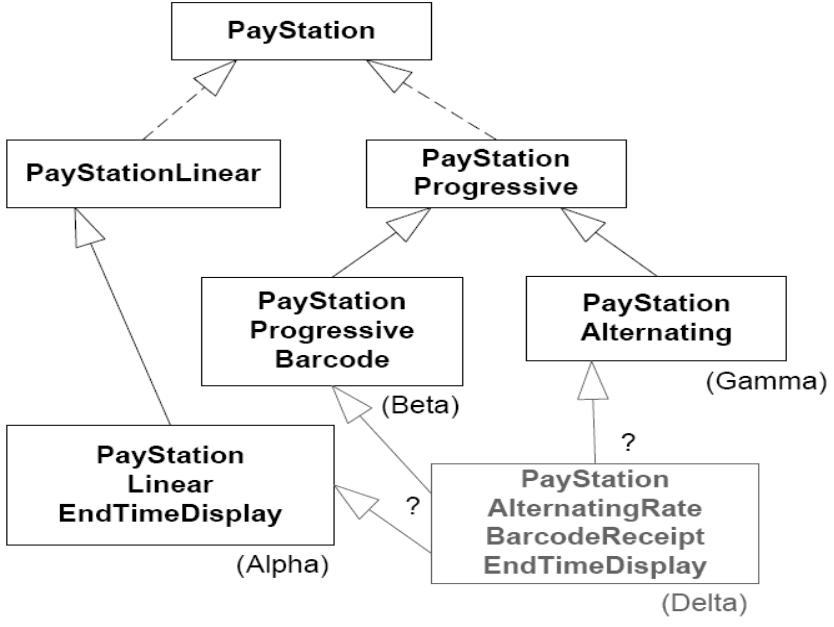
Polymorphic Variance

- Inheritance dies **miserably** facing this challenge!
- Just look at names!
- Making new variants is difficult.
- And code reuse is very difficult ☹



Masking the problem

- By **combining** parametric and polymorphic variance you may mask the problem somewhat.
- I.e. handle receipt type by inheritance, and the rest by pumping the code with if's…
- but … it is still an inferior way to handle multi-dimensional variance…

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Compositional software

- The way forward is:
  - ***Compositional software***
  - Highly configurable and flexible software!

- ③ Consider what behavior that may vary
- ① Express variable behavior as a responsibility clearly defined by an interface
- ② Delegate to object serving the responsibility to perform behavior

- ③ Encapsulate what varies
  - The display output must exist in variants
- ① Program to an interface
  - <<interface>> DisplayStrategy
    - public int calculateOutput(int minutes);
- ② Favor object composition

```
public int readDisplay() {
  return displayStrategy.calculateOutput(timeBought);
}
```

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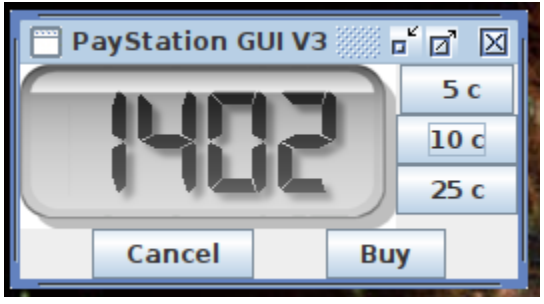
Compositional software

- [Demo]



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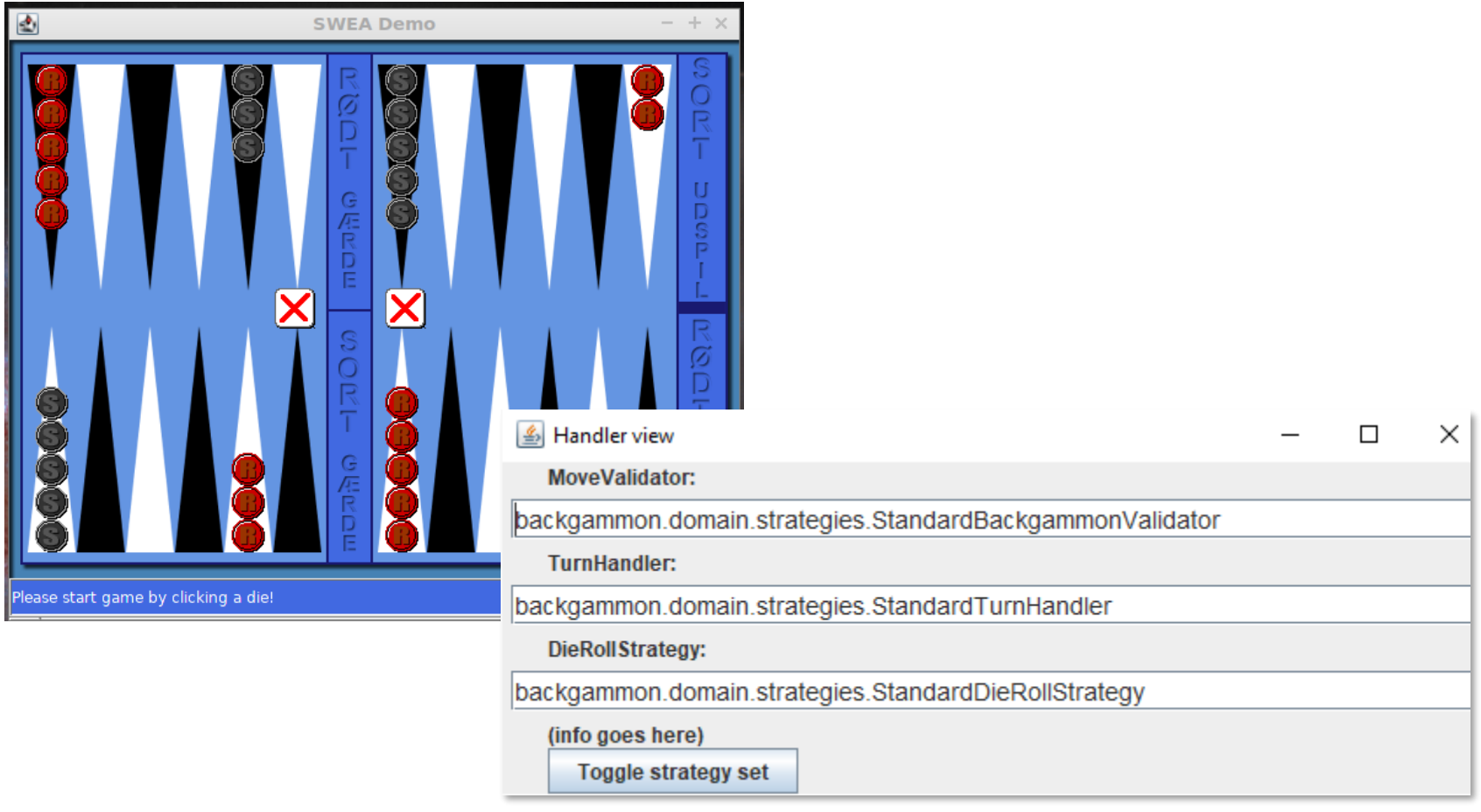
Compositional Software



Compositional Software

- The paystation has become a *team leader*, delegating jobs to specialist workers:

```
public int readDisplay() {
  return displayStrategy.calculateOutput(timeBought);
}
```

```
timeBought = rateStrategy.calculateTime(insertedSoFar);
```

```
public Receipt buy() {
  Receipt r = factory.createReceipt(timeBought);
  reset();
  return r;
}
```

- Note! No if's – no bloat – easy to read code leading to fewer bugs!

Compositional Software

- Telling the team leader which persons will serve the roles:

- The factory interface

```
public interface PayStationFactory {
  /** Create an instance of the rate strategy to use. */
  public RateStrategy createRateStrategy();

  /** Create an instance of the receipt.
   * @param the number of minutes parking time the receipt is valid for. */
  public Receipt createReceipt( int parkingTime );

  /** Create instance of DisplayStrategy */
  public DisplayStrategy createDisplayStrategy();
}
```

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Compositional Software

- Creating a pay station:
  - create the factory
  - create the pay station, giving it access to the factory

```
private PayStation paystation = new PayStationImpl(new AlphaTownFactory() );
```

Compositional Software

- ... and a factory:

```
public class BetaTownFactory implements PayStationFactory {
  public RateStrategy createRateStrategy() {
    return new ProgressiveRateStrategy();
  }
  public Receipt createReceipt( int parkingTime ) {
    return new StandardReceipt(parkingTime, true);
  }
  public DisplayStrategy createDisplayStrategy() {
    return new ValueDisplayStrategy();
  }
}
```

Analysis

- Benefits
  - The variability points are independent
    - we introduced new display strategy – but this did not alter any of the existing strategies !

```
public int readDisplay() {
  return displayStrategy.calculateOutput(timeBought);
}
```

  - Once the variability point has been introduced we can introduce as many new types of variations as we like – only by *adding* new classes
    - any price model; new receipt types; new display output...
  - **Open-closed principle in action...**

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Open/Closed principle

Open for extension

Closed for modification

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Open/Closed principle

- **Open** for extension
  - I can make my own feature additions/changes by extending the software
- **Closed** for modification
  - But I do not rewrite any existing code
    - Or ask Oracle, Google, NetFlix, Apache, to rewrite code to handle my extensions

- (i.e. no soldering of wires in my TV set)

Analysis

- Benefits
  - Any combination you want, we are able to “mix”
  - Nonsense combinations can be delimited
    - abstract factory is the place to “mix” the cocktails
  - Code readability
    - every aspect of the configuration is clearly defined in a single place
      - configuration mixing in the abstract factory
      - orchestration in the PayStation impl
      - each variation type in its own implementing class

Analysis

- Liabilities
  - Each dimension of variability (price model, receipt type, display output, etc) is *really* independent – so
  - we cannot feed information from one to the other directly ☹
  - If they require information from each other
    - Then of course we must provide the means to do so
      - Mediator pattern, memento pattern, observer pattern, others
    - Like we do in mandatory project
      - StandardGame calls strategy with ‘this’ ala a Private Interface
      - The Strategy calls mutators on the MutableGame

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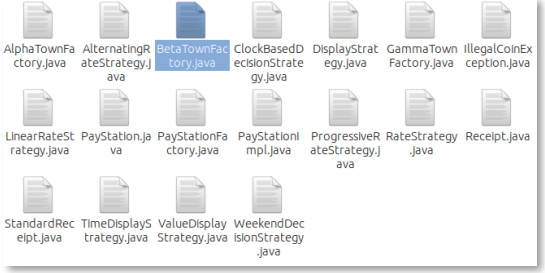
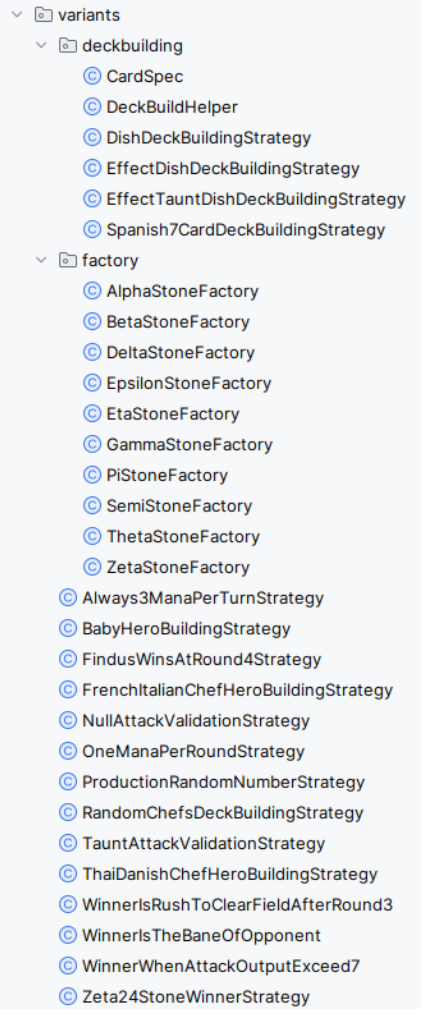
Analysis

- Liabilities
- The number of classes in action ☹

- On the other hand:
  - careful naming makes it possible to quickly identify which class to change…
- And use packages to group cohesive modules





Analysis

- Liabilities
  - Actually I have a combinatorial explosion of factories! I need a factory for each and every combination of delegates that I have
  - Exercise: How can I avoid this explosion?

Another Example

SkyCave

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Configuration System

- Six roles of variability
  - Storage system
  - Network connector
  - Authentication
  - External services
  - Name Service
  - Logging System
- AbsFactory reads a *CPF property file*
  - *Impl class*
  - *Network host and port*

```
# Setting everything for socket based connection on
# LocalHost with (mostly) test doubles. Also acts as base CPF
# for remote configurations of daemon.

# === Configure for socket communication on server side
SKYCAVE_SERVERREQUESTHANDLER_IMPLEMENTATION = frds.broker.ipc.socket.SocketServerRequestHandler

# === Configure for server to run on localhost
SKYCAVE_APPSERVER = localhost:37123

# === Inject test doubles for all delegates (Note IP endpoints are dummies)

# = Subscription service
SKYCAVE_SUBSCRIPTIONSERVICE_CONNECTOR_IMPLEMENTATION = cloud.cave.doubles.TestStubSubscriptionService
SKYCAVE_SUBSCRIPTIONSERVICE_SERVER_ADDRESS = notused:42042

# = Cave storage
SKYCAVE_CAVESTORAGE_CONNECTOR_IMPLEMENTATION = cloud.cave.doubles.FakeCaveStorage
SKYCAVE_CAVESTORAGE_SERVER_ADDRESS = notused:27017

# = Quote service
SKYCAVE_QUOTESERVICE_CONNECTOR_IMPLEMENTATION = cloud.cave.doubles.TestStubQuoteService
SKYCAVE_QUOTESERVICE_SERVER_ADDRESS = notused:6777

# = Player Name Service - defaults to the simple in memory one which
# operates correctly in a single server/single threaded non-loaded setting
SKYCAVE_PLAYERNAMESERVICE_CONNECTOR_IMPLEMENTATION = cloud.cave.server.InMemoryNameService
SKYCAVE_PLAYERNAMESERVICE_SERVER_ADDRESS = notused:11211

# = Inspector implementation - defaults to the simplest in memory one
SKYCAVE_INSPECTORSERVICE_CONNECTOR_IMPLEMENTATION = cloud.cave.server.SimpleInspector
SKYCAVE_INSPECTORSERVICE_SERVER_ADDRESS = notused:0
```

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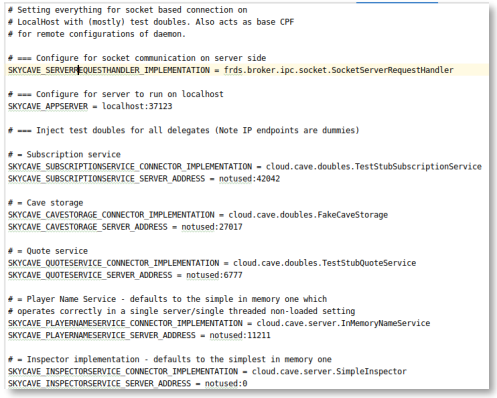
Configuration System

- Six roles of variability
  - Storage system (5)
    - FakeObject, MongoDB, Redis, Memcached, MariaDB
  - Network connector (3)
    - Sockets, HTTP, RabbitMQ
  - Authentication (3)
    - TestStub, NullObject, RealService
  - External services (2)
    - TestStub, RealService
  - Name Service (2)
    - In memory, Memcached
  - Logging System (2)
    - In memory, Memcached



SkyCave can exist in 5*3*3*2*2*2

= 360 variants

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And No Code Clutter

```
// Fetch the player object from the name service
Player player = objectManager.getPlayerNameService()
        .get(playerId);
```

```
SubscriptionService subscriptionService = objectManager.getSubscriptionService();

// Fetch the subscription for the given loginName
SubscriptionRecord subscription = null;
String errorMsg = null;
try {
  subscription = subscriptionService.lookup(loginName, password);
} catch (CaveIPCException e) {
  errorMsg="Lookup failed on subscription service due to IPC exception:"+e.getMessage();
  logger.error(errorMsg);
}
```

```
QuoteRecord quoteRecord =
        objectManager.getQuoteService().getQuote(quoteIndex);
String quote = convertToStringFormat(quoteRecord);
return quote;
```

```
public void addMessage(String message) {
  MessageRecord msg = new MessageRecord(message, getID(), getName());
  storage.addMessage(getPosition(), msg);
}
```

- *An object manager keeps track of all delegates ☺*

Summary

Handle multi-dimensional variance by compositional software designs !