



A Model-Based Framework for On-Board Software

Small Satellite Conference 2021

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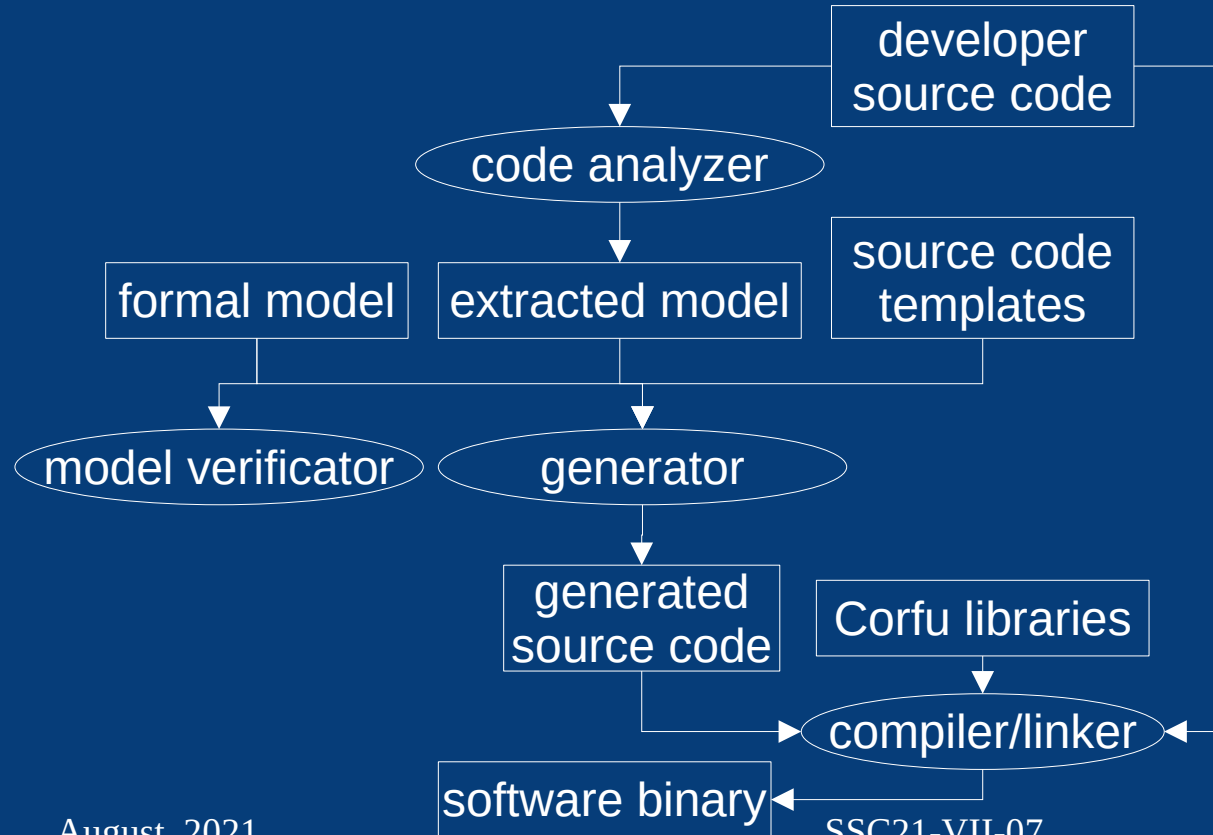
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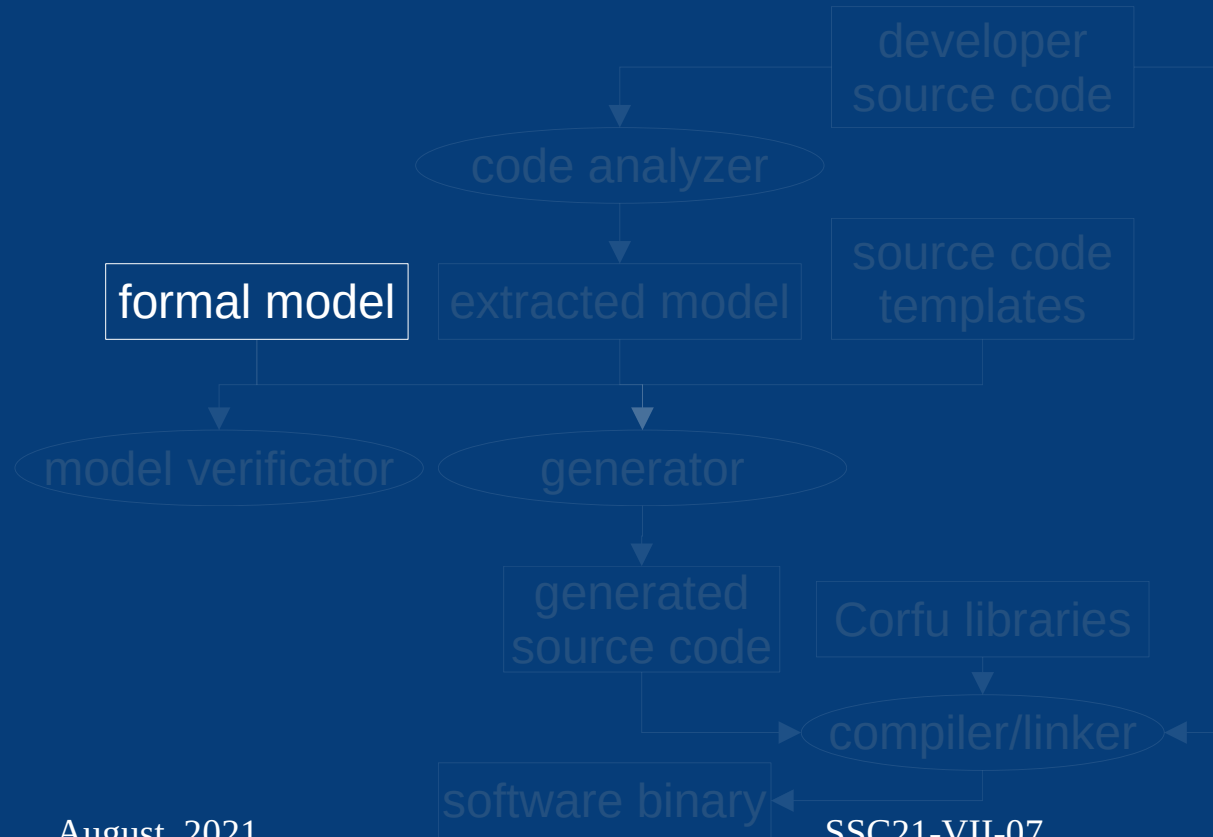
Corfu

- **Configurable On-Board Software Framework for You**
- (Extended) Model-based approach
- Builds on the RTOS Rodos
- Uses the communication middleware of Rodos

Development Process



Development Process



Formal Model

- App-centric design
- Main entities:
 - Apps
 - Nodes
 - Topics

- Threads
- Internal Communication Interface
 - Topic Subscriptions
 - Topic Publications
- External Communication Interface
 - Telecommands
 - Telemetry (real-time and extended)

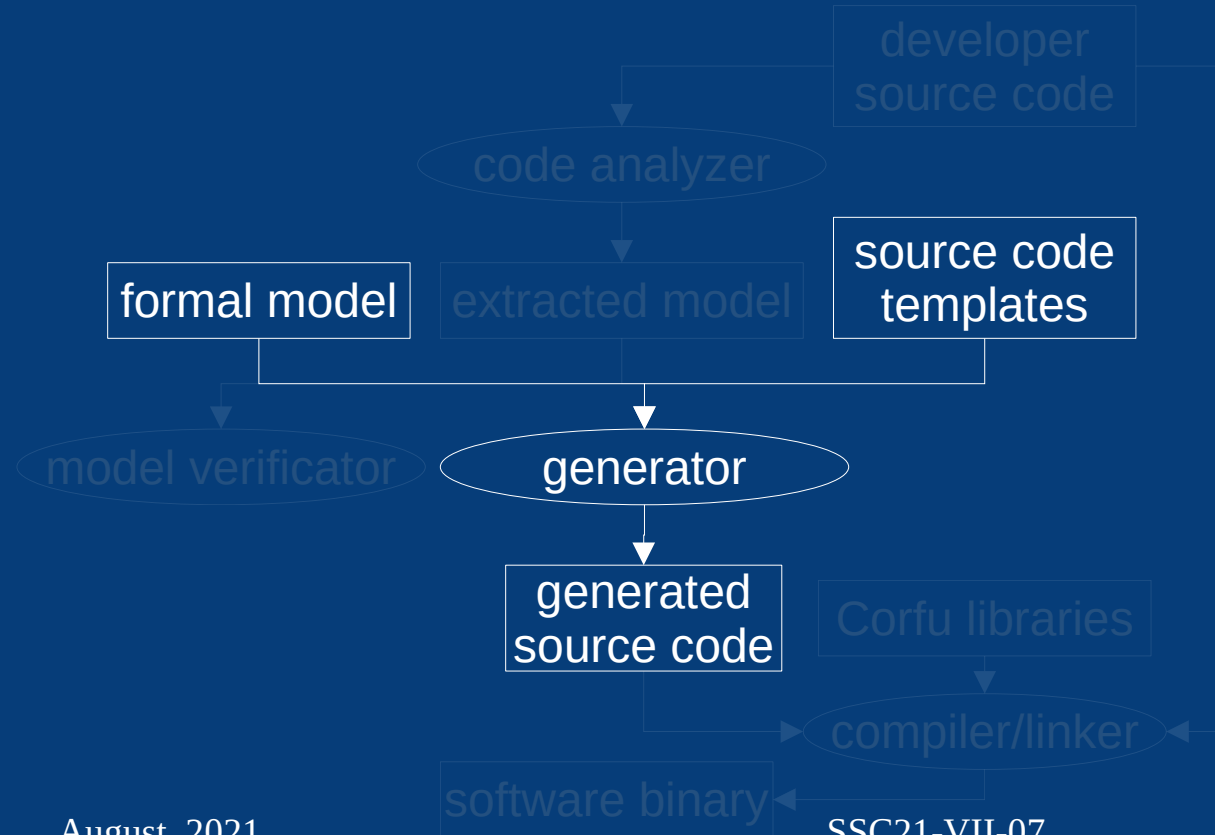
App Model

- Compile-time parameters
- Run-time parameters

Node Model

- List of Apps
- List of Topics
- Connection between Topics and Apps
 - Publications
 - Subscriptions

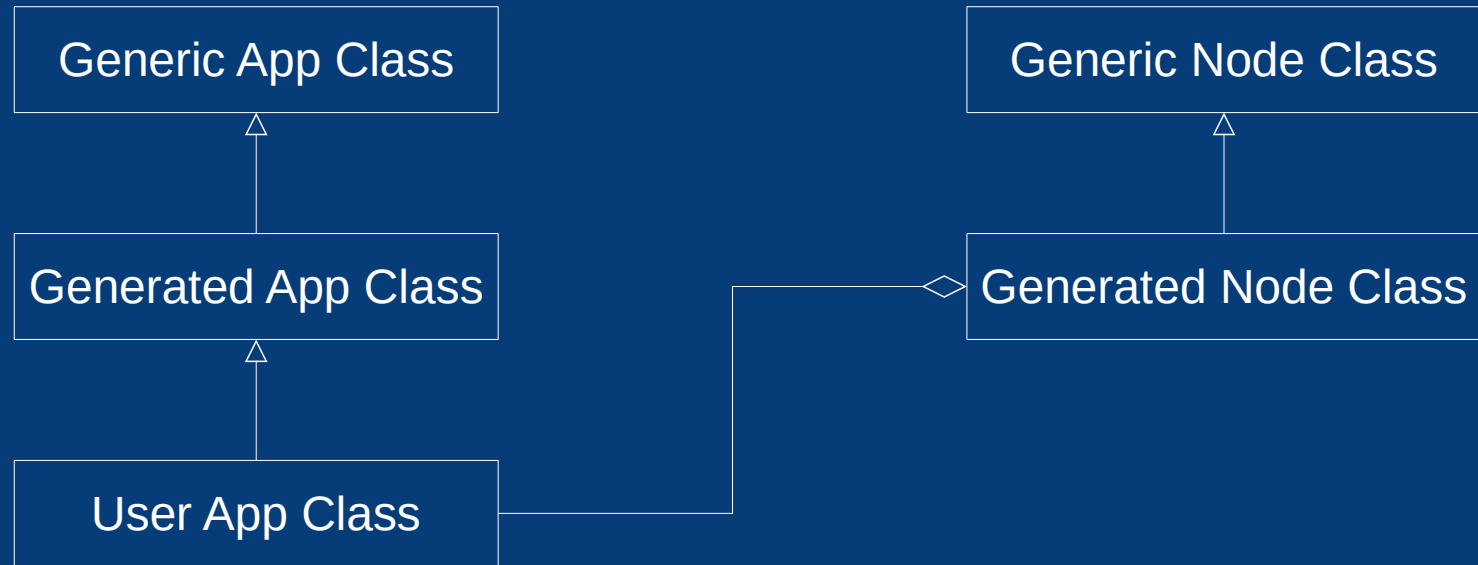
Development Process



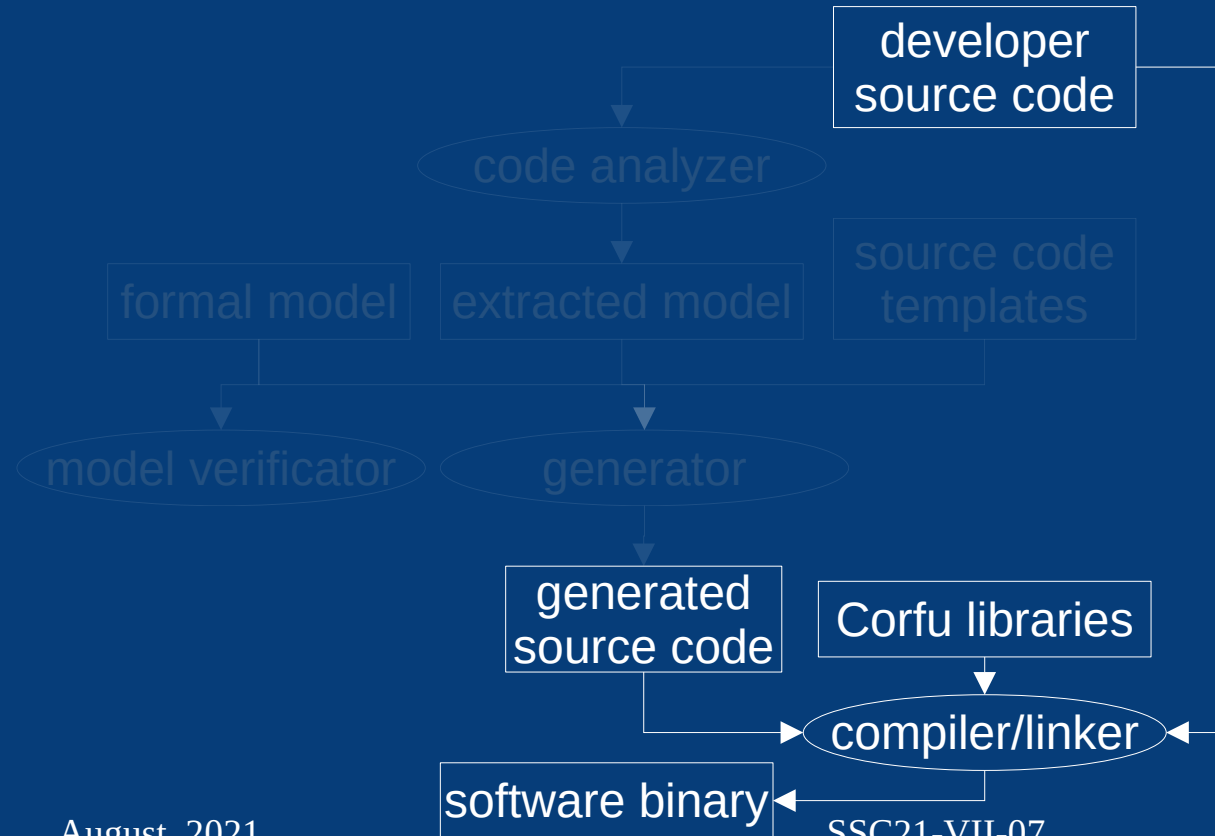
Generator

- Parses the formal model configuration (via libcorfu-config-parser)
- Processes the template files (via inja templating engine)
- Generates source code and cmake configuration for each app and node

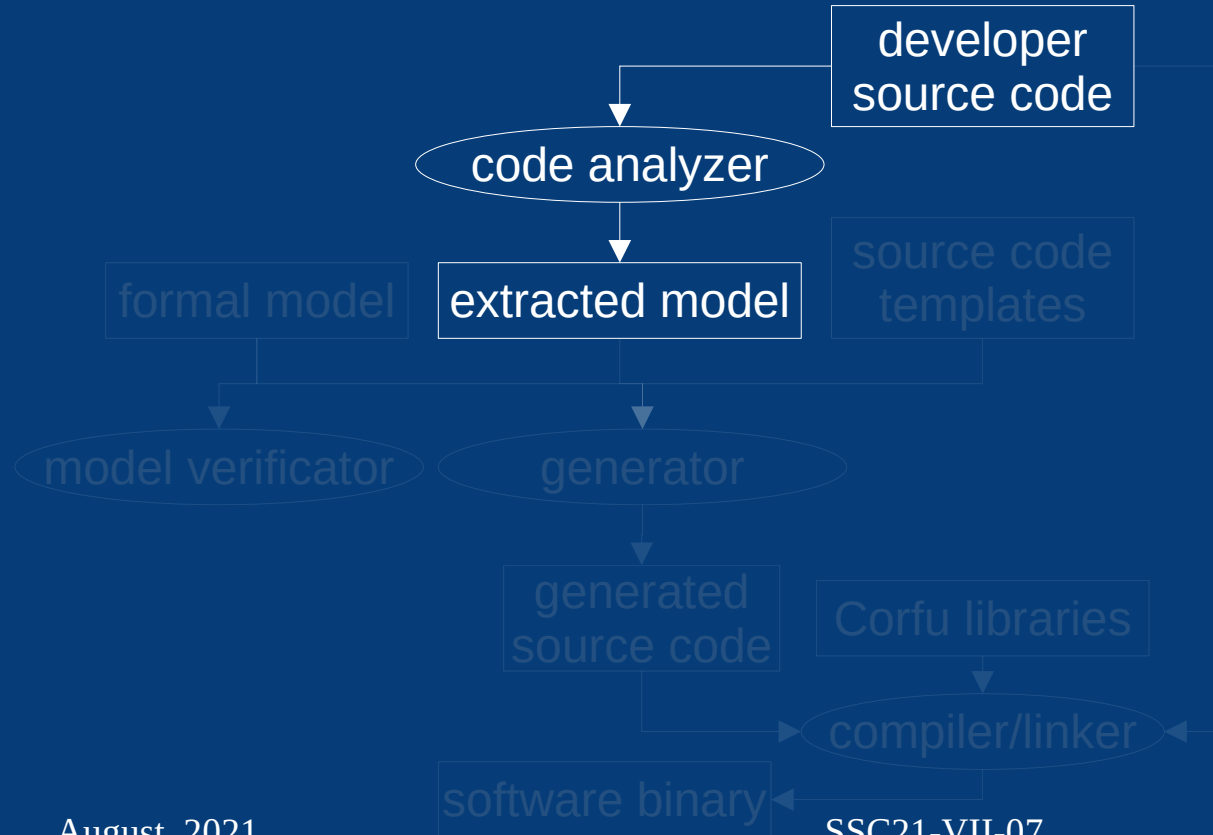
Generated Source Code



Development Process



Development Process

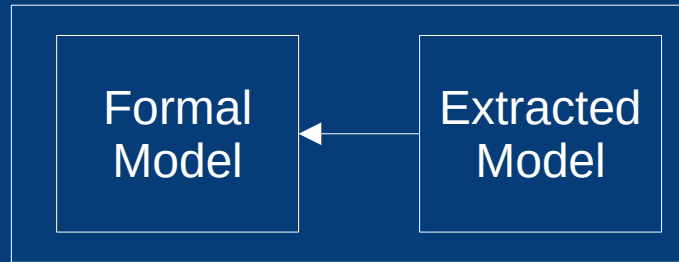


Code Analyzer

- Uses Clang AST
- Extracts information from source code
- Extends formal model

Extended Model

Extended Model



- Information from the source code can be used
 - at compile-time
 - at run-time

Example: Logging System

```
LOG(Severity::INFO, "everything's fine")
```

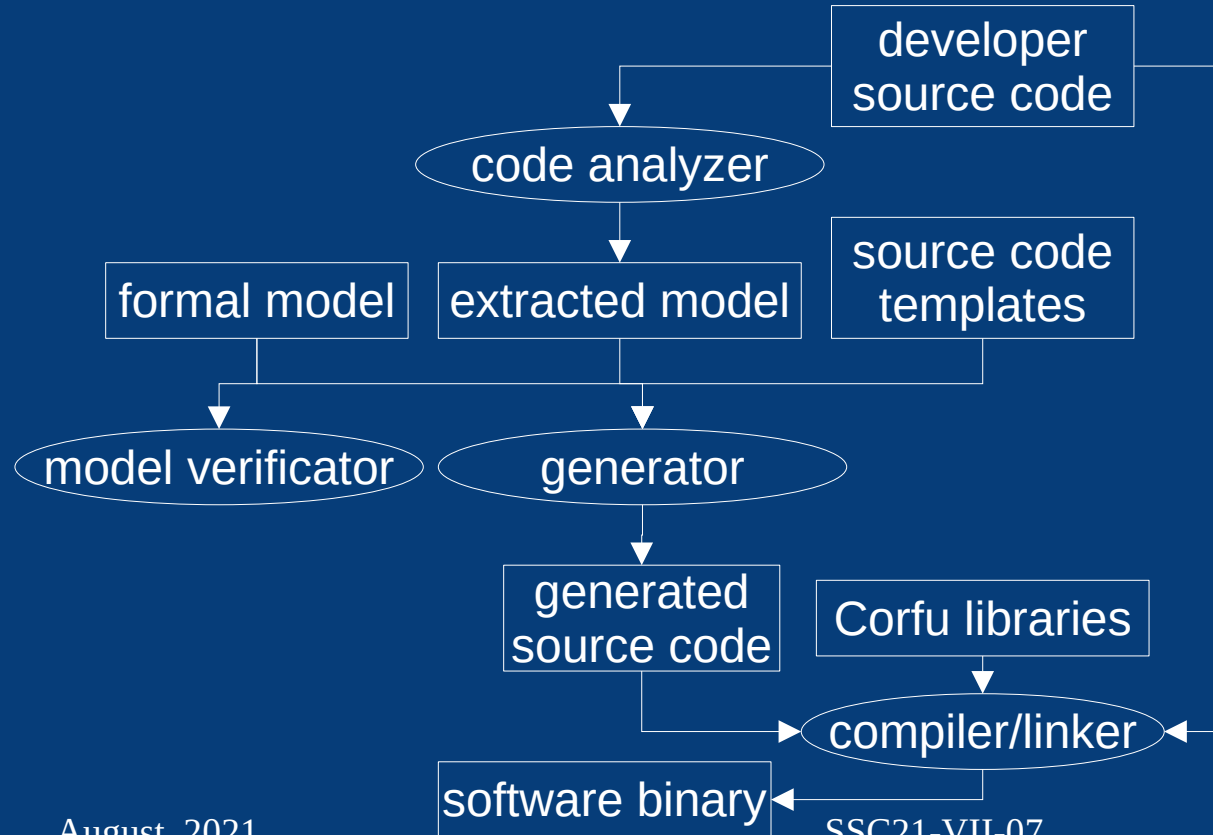
```
#define LOG(severity, message) log((severity), hash(message))
```

- `hash(...)` is defined `constexpr`
 - Hash value is calculated at compile-time
 - String does not land in binary file, just the hash value
 - String is not transmitted to ground, just the hash value

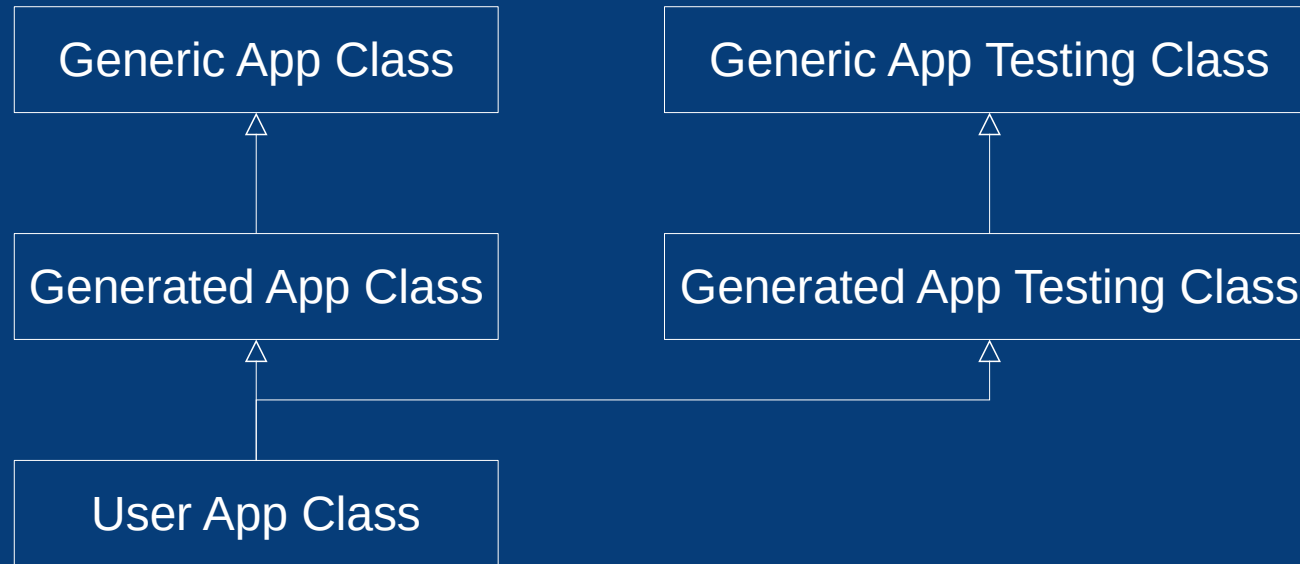
Example: Logging System

- The model is extended with a mapping of hash values to messages (+ parameter types)
- Ground software uses the extended model to interpret logging messages

Development Process



Unit Testing



Corfu in Action

- InnoCube
 - CubeSat by JMU Würzburg and TU Berlin
 - 6 different computing nodes
 - more than 20 different apps
 - Launch in 2023

Conclusion

- A software suite for creating custom software satellite
- Still in early development
- Enables new features and improved performance by automatic model extension through source code analysis