Software Process in Geant4

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Outline

- Overview on Software Processes
- The area of application
- Life-cycle processes in Geant4
- Software Process Improvement
  - Future evolutions
- Conclusions
Definitions...

Software Process

- A set of interrelated activities, which transform inputs into outputs (*ISO 12207/8402*)
  - used by an organisation or project to plan, manage, execute, monitor, control and improve any software related activity
- Life-cycle processes are structured in *dimensions*:
  - Primary processes
    - includes all major functions of software development
  - Supporting processes
    - for supporting other processes with a purpose
  - Organisational processes
    - for corporate level management and improvement
### Process Architecture

#### Customer-Supplier
- CUS.1 Acquisition
  - CUS.1.1 Acquisition Preparation
  - CUS.1.2 Supplier Selection
  - CUS.1.3 Supplier Monitoring
  - CUS.1.4 Customer Acceptance
- CUS.2 Supply
- CUS.3 Requirements Elicitation (*)
- CUS.4 Operation
  - CUS.4.1 Operational Use
  - CUS.4.2 Customer Support (*)

#### Engineering
- ENG.1 Development
  - ENG.1.1 System Requirements A&D
  - ENG.1.2 Software Requirements Analysis
  - ENG.1.3 Software Design (*)
  - ENG.1.4 Software Construction (*)
  - ENG.1.5 Software Integration
  - ENG.1.6 Software Testing
  - ENG.1.7 System Integration & Testing (*)
- ENG.2 System & Software Maintenance (*)

#### Support
- SUP.1 Documentation (*)
- SUP.2 Configuration Management (*)
- SUP.3 Quality Assurance
- SUP.4 Verification
- SUP.5 Validation
- SUP.6 Joint Reviews
- SUP.7 Audit
- SUP.8 Problem Resolution

#### Management
- MAN.1 Management
- MAN.2 Project Management
- MAN.3 Quality Management
- MAN.4 Risk Management

#### Organisation
- ORG.1 Organisational Alignment
- ORG.2 Improvement
  - ORG.2.1 Process Establishment
  - ORG.2.2 Process Assessment
  - ORG.2.3 Process Improvement (*)
- ORG.3 Human Resource Management
- ORG.4 Infrastructure
- ORG.5 Measurement
- ORG.6 Reuse
The area of application: Geant4

- More than 1200 classes distributed in 17 Categories
  - software components in the Booch terminology
  - complex Categories organised in a hierarchical structure
- Decomposition to domain Categories derived from the design Category diagram
  - one development team associated to one Category domain
The area of application: Geant4

- Development teams distributed world-wide
  - domain decomposition <> geographical location of teams
  - centralized coordination of domain Categories
  - local coordination of each Working Group
    - assignment of responsibilities and support
  - distributed resources and funds in a *dynamic* environment

- Coordination for a coherent development
  - computing environment, methods and tools
Requirements Elicitation

- General User Requirements (UR) collected during the R&D phase of the project (RD44)
  - GEANT3 user community involved
  - URD generated according to the ESA PSS-05 software engineering standard
  - regular update and versioning of the URD along the development process

- Change-management based on CVS
  - general URD currently under revision
  - maintenance and tracking of specific detailed URDs under responsibility of WG coordinators

- New requirements approval: by the TSB
  - ongoing process improvement
Software Design

- Adoption of the *Booch* methodology for OOAD since the R&D project start
  - chosen after deep evaluation of the existing methodologies (‘94)
  - tailored to project specific needs
  - supported by CASE tools (*Rational-Rose*)
  - UML notation adopted for design documents
    - Category diagrams, Class diagrams, Scenario diagrams, Class specifications
  - ongoing process improvement

- Software development structured in *macro* and *micro* processes showed very effective
  - *iterative* & *incremental* approach (*spiral* model)
  - loose domain coupling led to efficient WG structure
Software Construction

- Software packaging reflects the domain decomposition in Categories
  - Packaging of Categories and sub-Categories in relation to definition of abstract and concrete interfaces (*frameworks*)
    - Provide a set of services in a *re-usable* way
    - Software *toolkit* approach

- Essential and flexible guidelines for coding

- Code filtering with specialised tools
  - *Code Wizard*
  - both in the **global** and **unit** context
    - tool accessible from Web
System Testing

- Activity deployed to a specialised team (STT)
  - based on defined procedures
    - CVS tagging policy
    - automated through Web tools and scripts
      - Bonsai, LXR, Tinderbox
      - ongoing process improvement
    - test applications used also for system integration
      - run & tested on every supported platform/compiler
      - ongoing process improvement
  - user example applications used for acceptance

- Category tags submitted to testing in sequence according to the dependency flow dictated by the design category diagram

- Close collaboration with the release manager
## CVS Tags

Tags to directory `gensec` on all tags in canonical form since the last 2 `Global` tag.

<table>
<thead>
<tr>
<th>Date</th>
<th>Who</th>
<th>Directory</th>
<th>Tag</th>
<th>Status</th>
<th>Testarea</th>
<th>Sentence</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>08/30/2001</td>
<td>11:00</td>
<td>gensec</td>
<td>geant-03-02-ref-03</td>
<td>Internal</td>
<td>CVS</td>
<td>Proposed CVS</td>
<td>Coworks with code: V03-02-06. First developer release of G4Reco graphics.</td>
</tr>
<tr>
<td>08/30/2001</td>
<td>02:17</td>
<td>gensec/surface/visualization</td>
<td>vie-V03-02-14</td>
<td>Proposed</td>
<td>CVS</td>
<td>Proposed CVS</td>
<td>Coworks with vie-V03-02-14. For ExpRep driver.</td>
</tr>
<tr>
<td>08/30/2001</td>
<td>02:15</td>
<td>gensec/config</td>
<td>config-V03-02-06</td>
<td>Proposed</td>
<td>CVS</td>
<td>Proposed CVS</td>
<td>Corrections in G4UBatch to ignore the blank line.</td>
</tr>
<tr>
<td>08/29/2001</td>
<td>23:29</td>
<td>gensec/source/intercorss</td>
<td>intercorss-V03-03-06</td>
<td>Selected</td>
<td>Test1</td>
<td>Proposed CVS</td>
<td>Major revision: re-implementation of photon processes according to a major.</td>
</tr>
<tr>
<td>08/29/2001</td>
<td>18:27</td>
<td>gensec</td>
<td>emulac-V03-02-06</td>
<td>Internal</td>
<td>CVS</td>
<td>OK</td>
<td>Removed obsolete files in directories &quot;results&quot; and &quot;code&quot;.</td>
</tr>
<tr>
<td>08/29/2001</td>
<td>10:43</td>
<td>gensec</td>
<td>emulac-V03-02-07</td>
<td>Accepted</td>
<td>CVS</td>
<td>OK</td>
<td>G4UBatch now displays (G4cerr) the error message.</td>
</tr>
<tr>
<td>08/29/2001</td>
<td>09:21</td>
<td>gensec/source/run</td>
<td>run-V03-02-03</td>
<td>Selected</td>
<td>Test1</td>
<td>OK</td>
<td>Convert NULL to 0 in G4VEventManager.cc.</td>
</tr>
<tr>
<td>08/28/2001</td>
<td>15:09</td>
<td>gensec/tests</td>
<td>tests-V03-02-00</td>
<td>Selected</td>
<td>Test1</td>
<td>OK</td>
<td>All tests/examples fail at run-time on EP-aCC.</td>
</tr>
<tr>
<td>08/28/2001</td>
<td>08:01</td>
<td>gensec/source/intercorss</td>
<td>intercorss-V03-02-05</td>
<td>Internal</td>
<td>CVS</td>
<td>OK</td>
<td>All tests/examples fail at run-time on EP-aCC.</td>
</tr>
<tr>
<td>08/27/2001</td>
<td>07:57</td>
<td>gensec/source/event</td>
<td>event-V03-02-05</td>
<td>Selected</td>
<td>Test1</td>
<td>OK</td>
<td>To ensure repetiability between tracks &amp; events added method to emulac.cc.</td>
</tr>
<tr>
<td>08/27/2001</td>
<td>19:58</td>
<td>gensec/source/processes/</td>
<td>transportation</td>
<td>Rejected</td>
<td>CVS</td>
<td>OK</td>
<td>G4Sphere.cc bug fixed in G4Sphere_SurfaceNormal for the</td>
</tr>
</tbody>
</table>
Software Maintenance

- Adoption of standards
- Encapsulation of components
  - minimise coupling to reduce software complexity
  - regular monitoring of architectural dependencies
- Avoid system-dependent solutions in the source code as much as possible
  - centralise system configuration management
  - modular structure for architecture setups
- Avoid use of too “advanced” language features to maximise porting
- Traceability of updates
  - history files & regular tagging
  - disentangle development from bug-fixes
Customer Support

- Terms of the User Support are defined in the Memorandum of Understanding (MoU)
- Effort shared among WGs
  - contact persons defined for each WG
  - acting as experts in their specific domain
  - joint meetings with users and developers
- Problem Tracking System (*Bugzilla*) available to users
  - flexible design allowing easy customisation for Geant4
  - tokens automatically assigned to responsible persons
  - 300 reports submitted since tool in production
  - ongoing process improvement
- On-line documentation, training and FAQ on Web
- Source code and binaries available on Web and AFS
- *Hypernews* user forum available (hosted by SLAC)
Documentation

- Six user manuals available on-line
  - Introduction to Geant4
  - Installation Guide
  - User’s Guide for Application Developers
  - User’s Guide for Toolkit Developers
  - Physics Reference Manual
  - Software Reference Manual

- User examples: novice, extended, advanced

- Training kit: three module-structured courses

- Design documents

- Defined policy for update
Configuration Management - releases

- Defined policy for *major* and *minor* releases
  - 4 major releases, 4 minor releases, 6 patches published since in production (December ‘98)
  - policy periodically revised and updated
- Development releases distributed monthly to collaborators and developers
  - additional development releases if necessary
- Close collaboration with System Testing Team
  - acceptance tests, part also of system tests, are also run independently by the release manager
- Prompt collaboration from developers required during the public release phase
Software Process Improvement (SPI)

- Understand, determine and establish applicable procedures to Software development and maintenance of the software
- Make SPI a Software Process life-cycle driven
  ⇒ Primary life-cycle processes:
    - guarantee that the code quality will not degrade with time: SPI actions associated with a regular QA activity
    - assure that coupling will not increase with the growing complexity of the software
  ⇒ Improve overall usability and robustness of applications: improve quality, maintainability and reliability of the code
  ⇒ Assure continuity and integration of regular system testing within the normal Software development activity
Software Process Improvement (SPI)

- **(Chosen) Domains of applicability in Geant4:**
  - **Q/A & Optimisation activity**
    - applied to the software product in either global and component domain related context
  - **Analysis & Design software cycle**
    - identify the well established OOP procedure for development and maintenance – assessment based on ISO-15504
  - **Testing**
    - assure constant improvement and continuity to system testing

- **Action for improvement identified**
  - plan for SPI established
  - progressive implementation
Future evolutions

- Make SPI part of the software life-cycle
- Consider monitoring progress of the SPI program
  - regular check-points at *Category-Coordinator meetings*
    - regular update of status:
    - include activities addressing SPI in the Collaboration Workshops
- Iterate new assessments in future
  - extend assessment to uncovered (or partially covered) domains (testing, documentation, Software Management)
  - try improving Capability level
Conclusions

- Geant4, a challenging project for applying Software Processes
- Current strategy demonstrated to be effective and flexible
  - far from being perfect!
    - requires continuous monitoring and improvement
    - SPI must be life-cycle driven
  - organisational alignment