# Supporting Undo and Redo in Scientific Data Analysis

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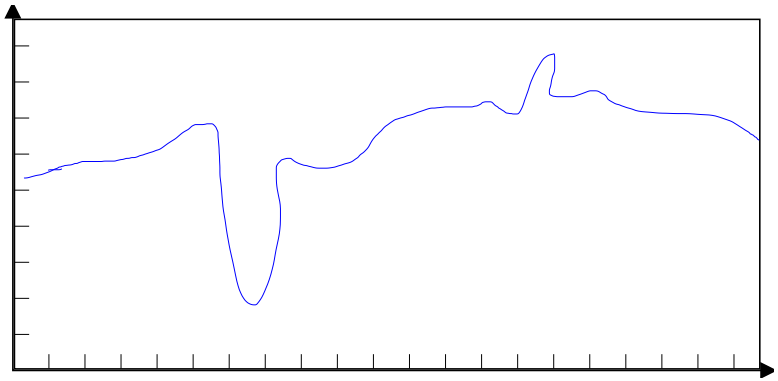
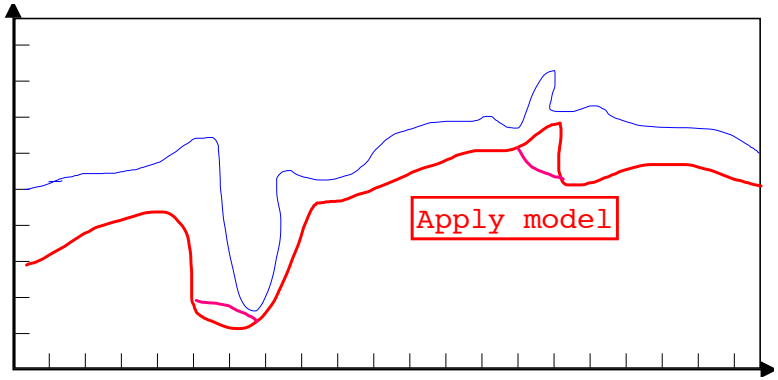
# Scientific Data Analysis



Raw Data

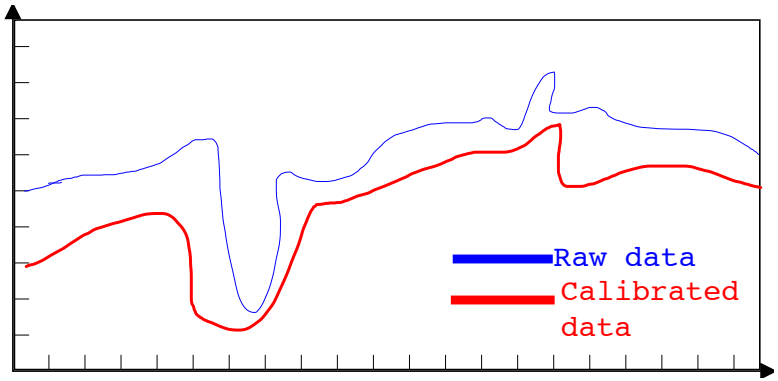


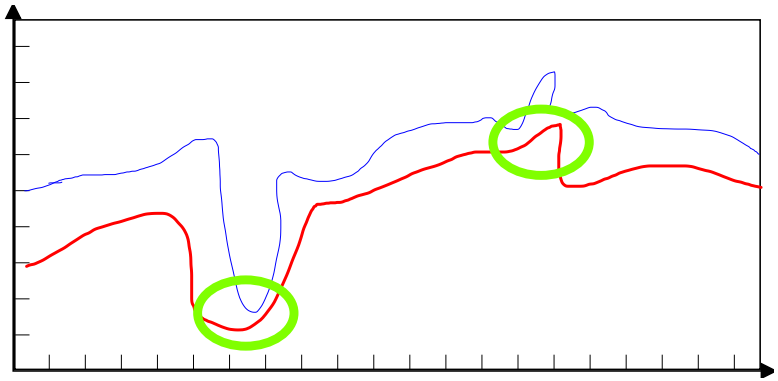

Gap-filled Data

↓

↑

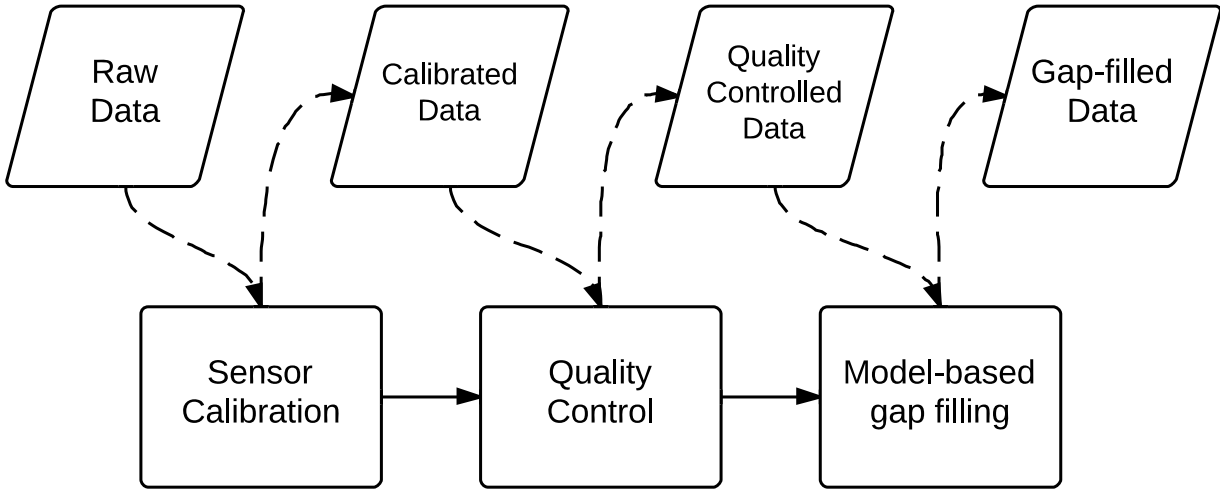
Calibrated Data → Quality Controlled Data



Scientific data goes through a series of complex transformations.

# Undo and Redo in Scientific Data Analysis



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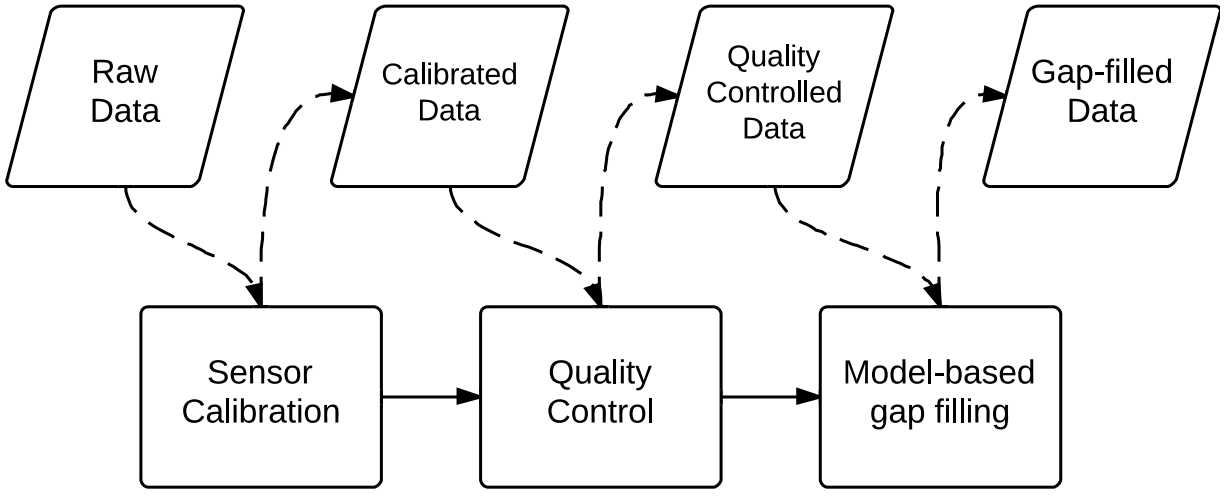


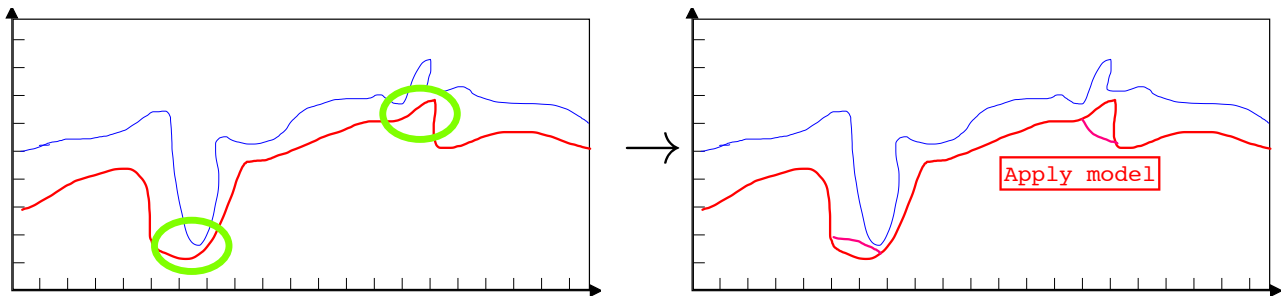


→apply another model?

- Transformations may be revisited as more information is available.

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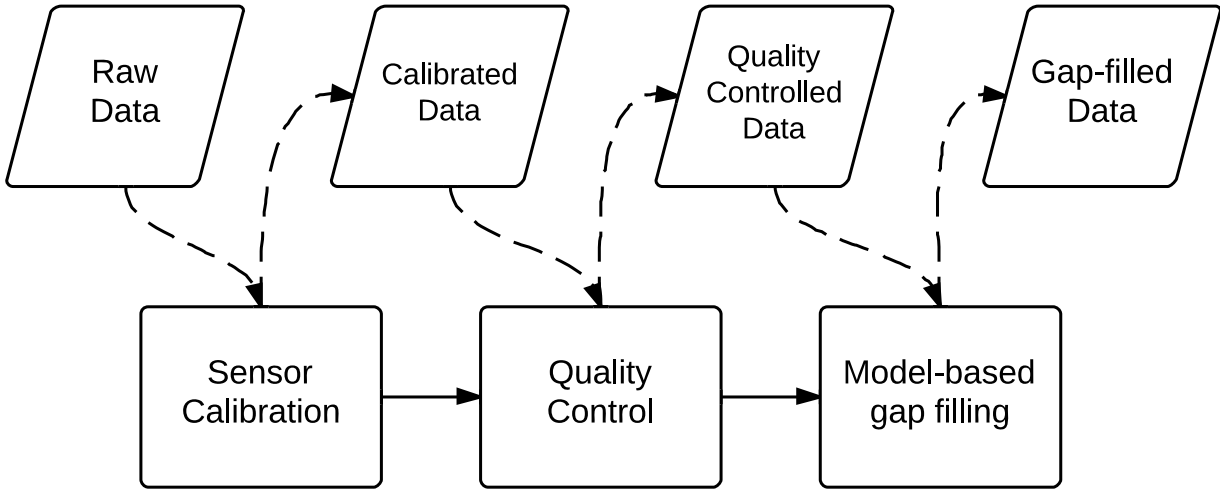


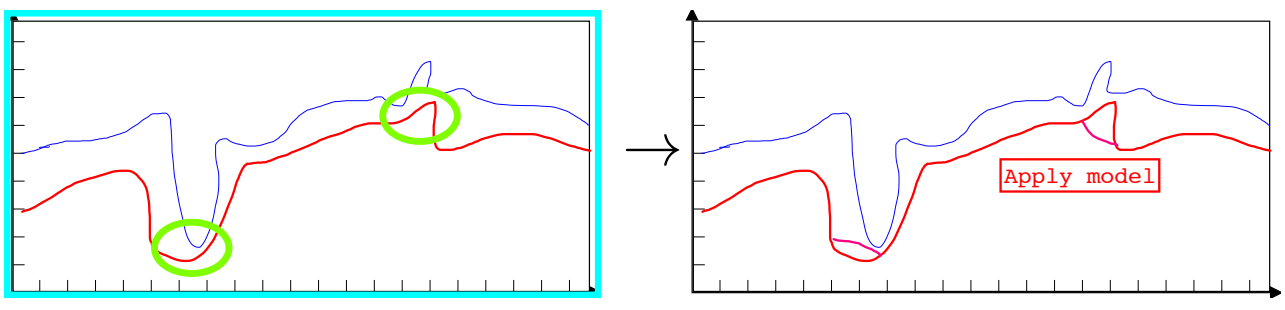


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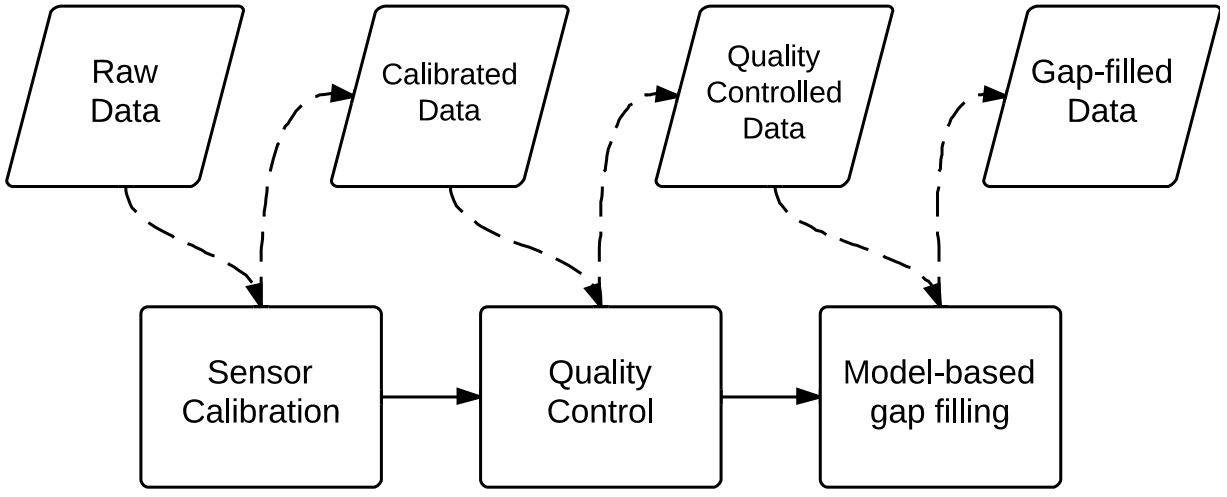


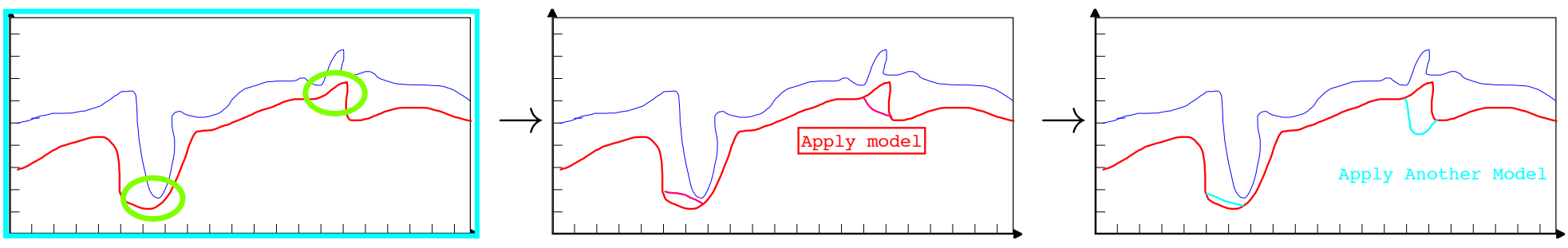


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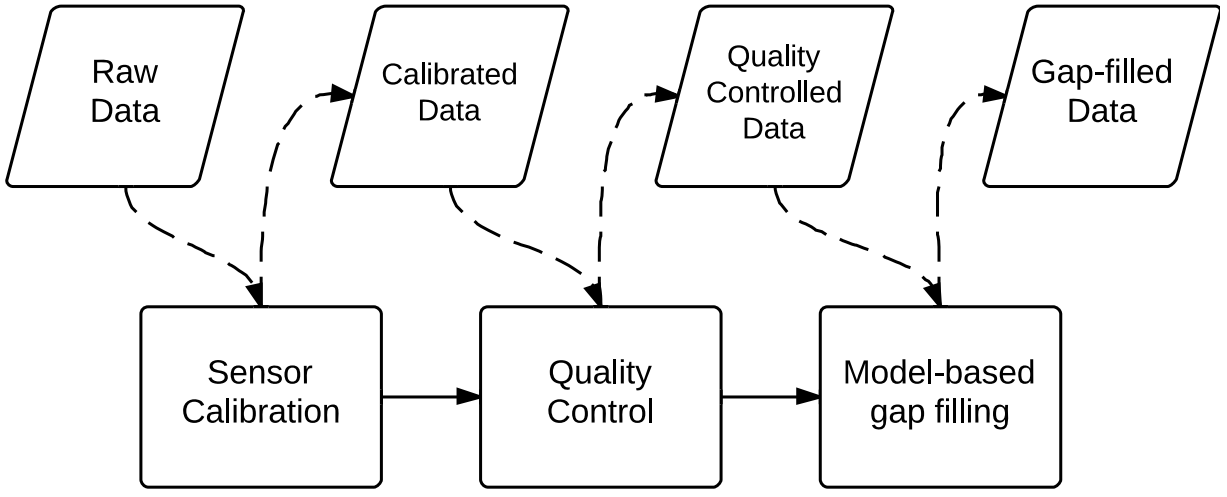


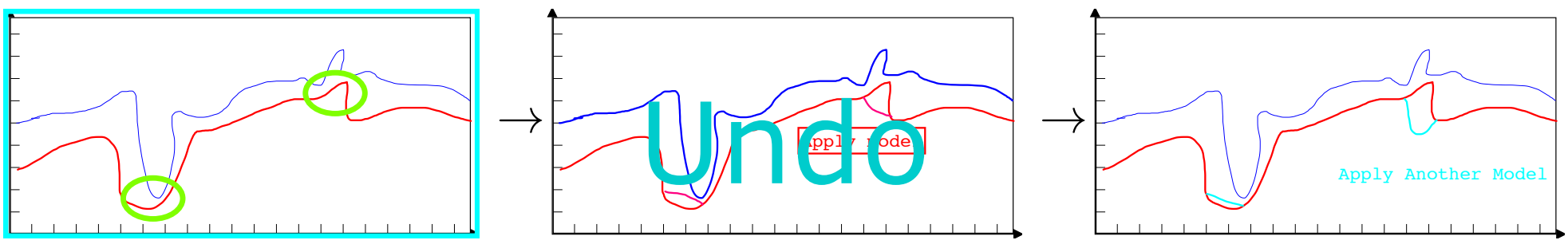


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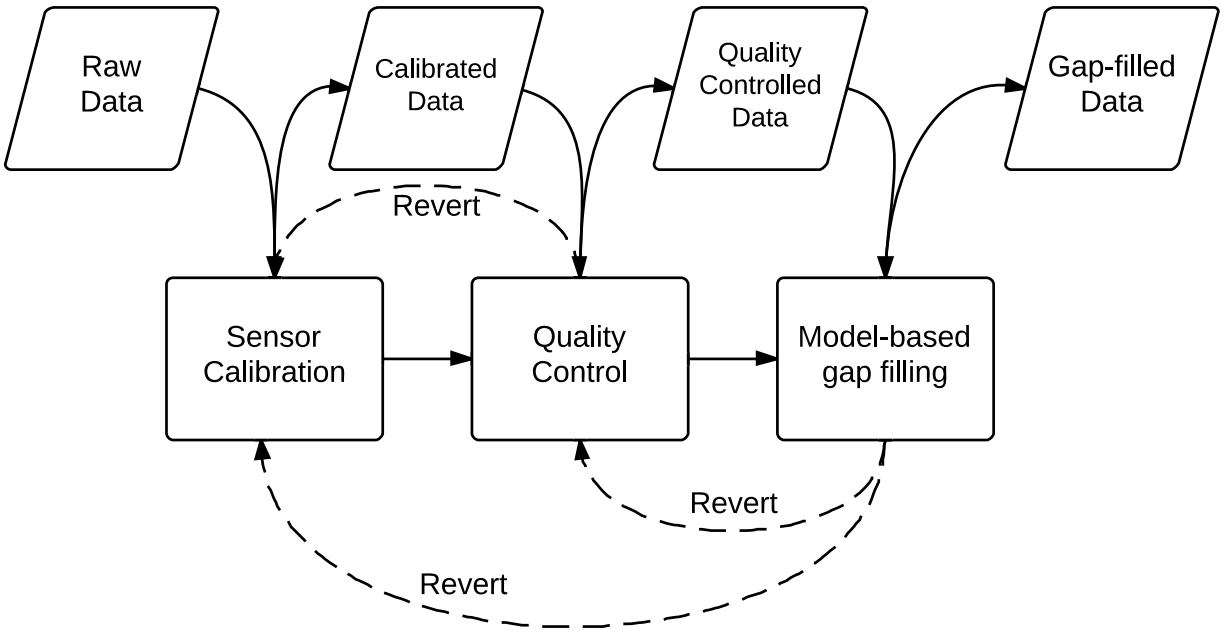
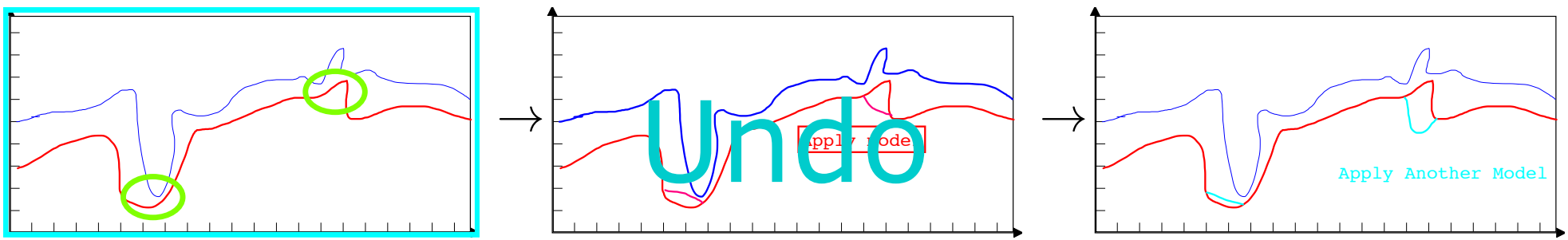
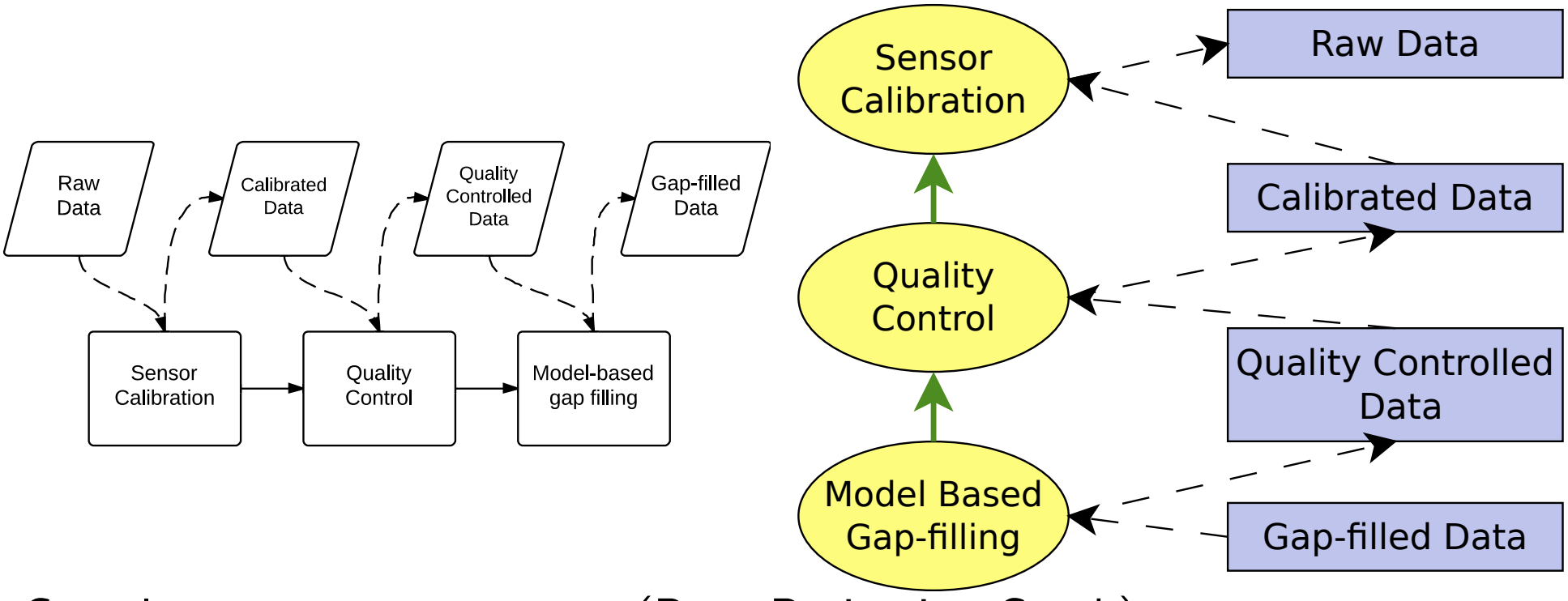



- Transformations may be revisited as more information is available.
- Undo and redo happen often
  - Undo and redo should not cause restarting from scratch.
  - Intermediate computations need to be taken advantage of.

# DDG: Provenance Support for Undo/Redo




Complete process provenance (Data Derivation Graph)

- Automatically records detailed process execution history
  - data creations and modifications
  - step execution sequences

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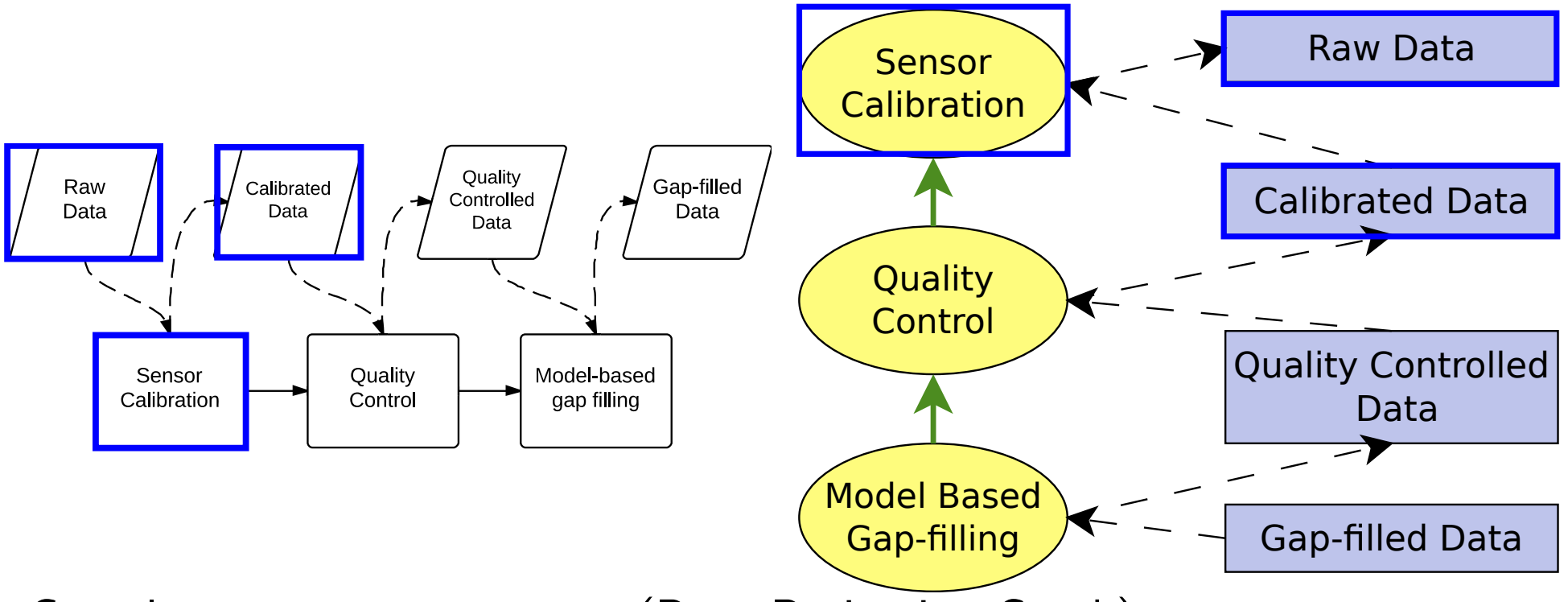


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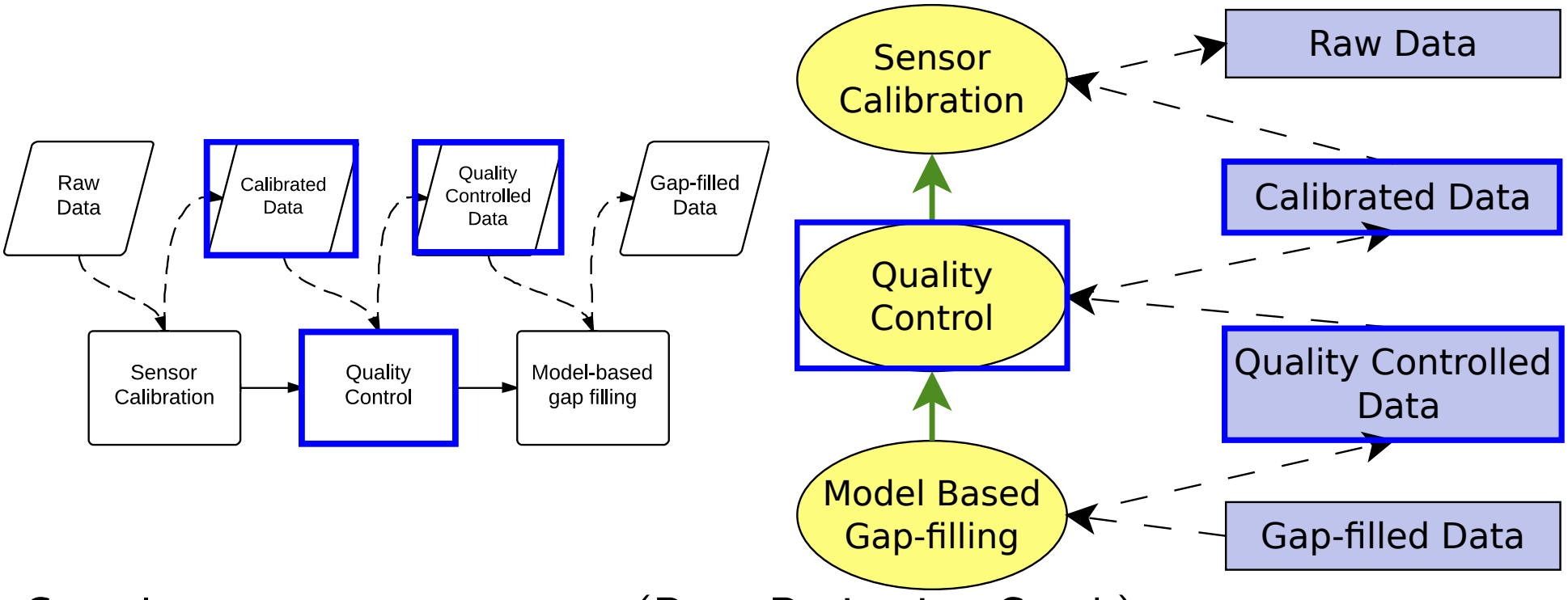


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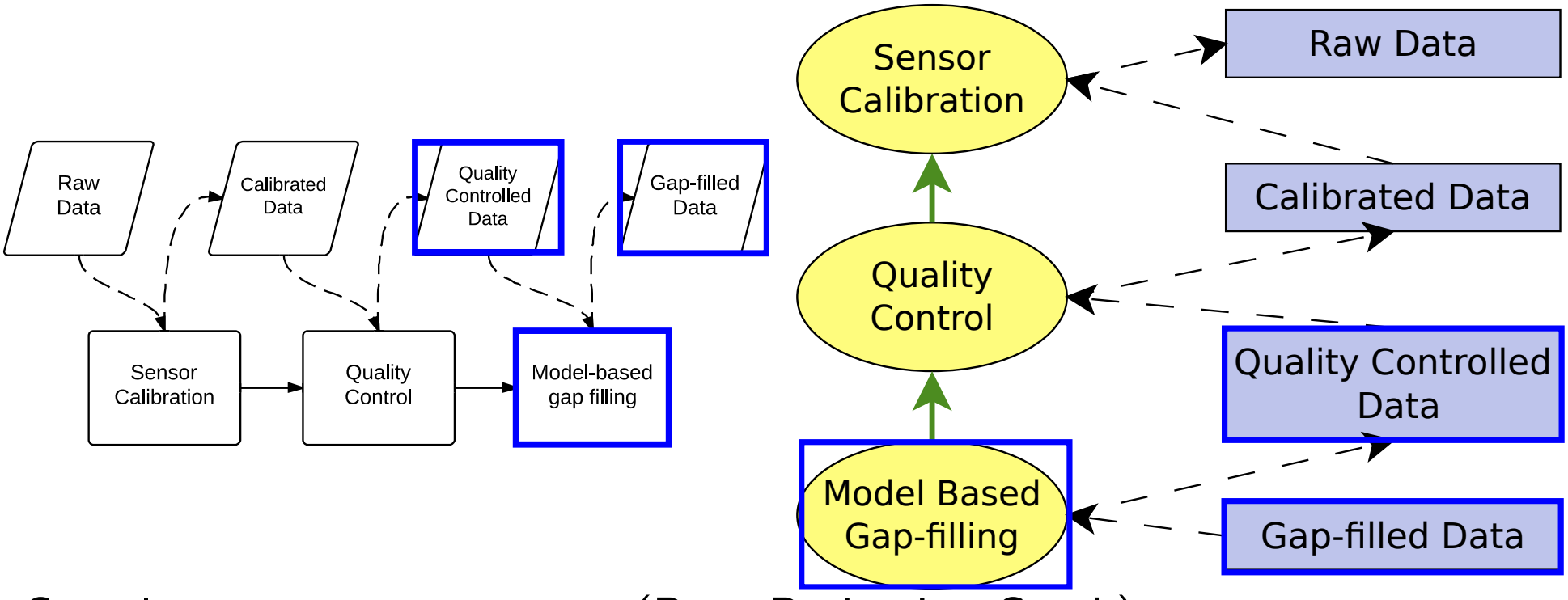


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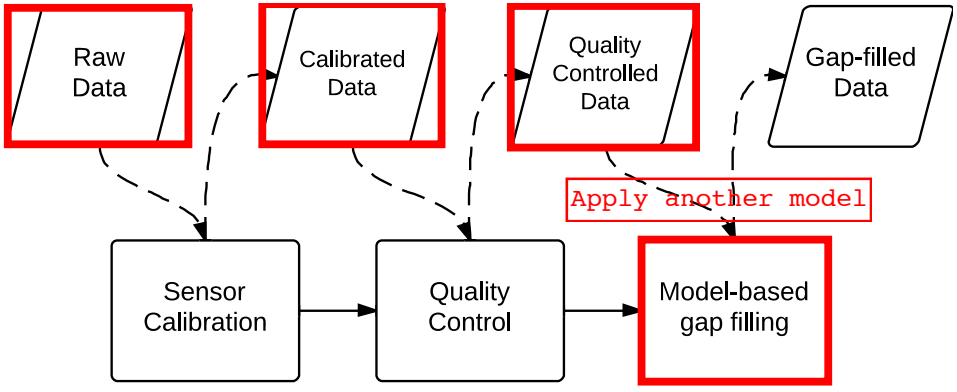


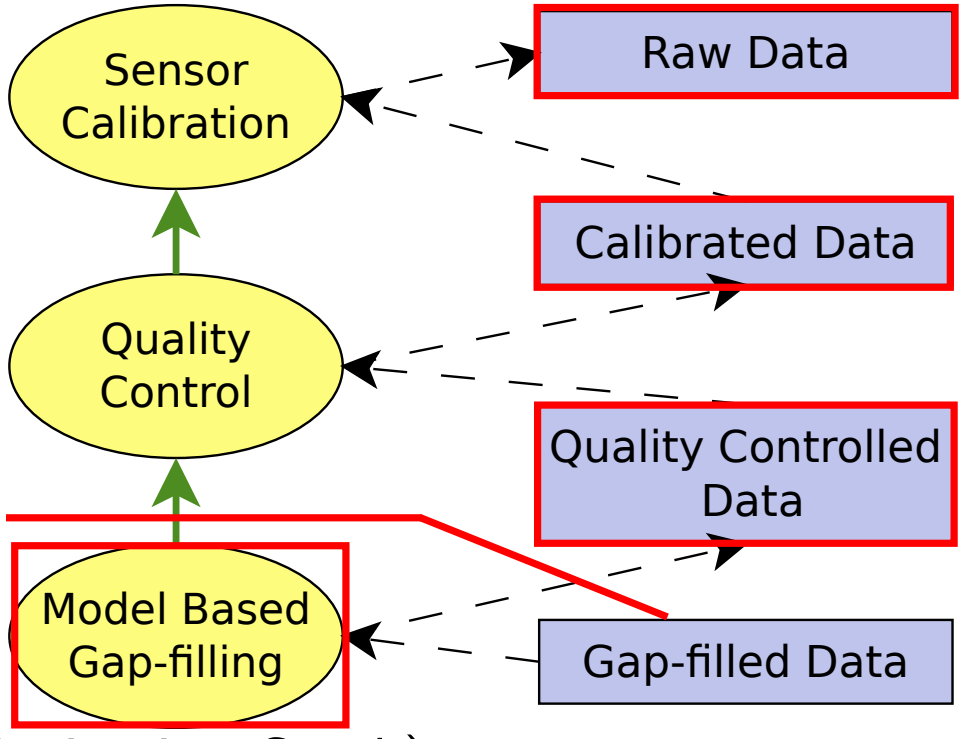


Complete process provenance (Data Derivation Graph)

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- Extracts process state at any given point

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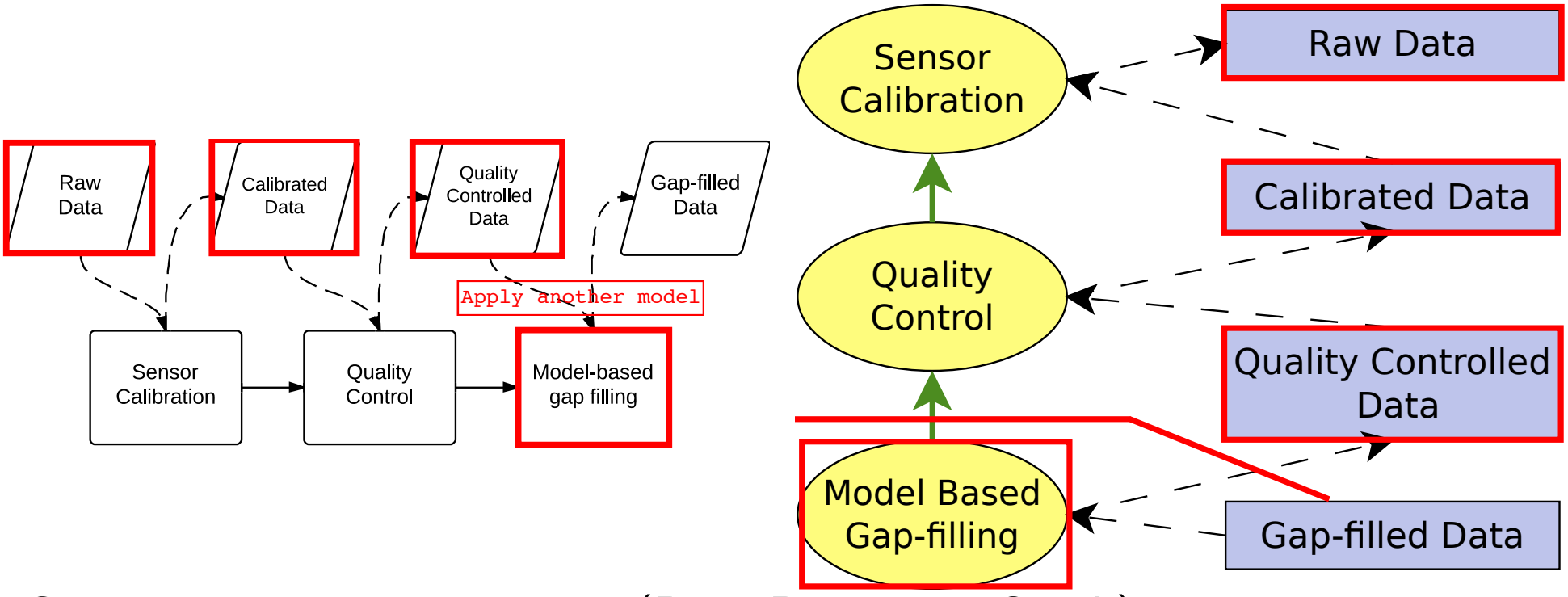
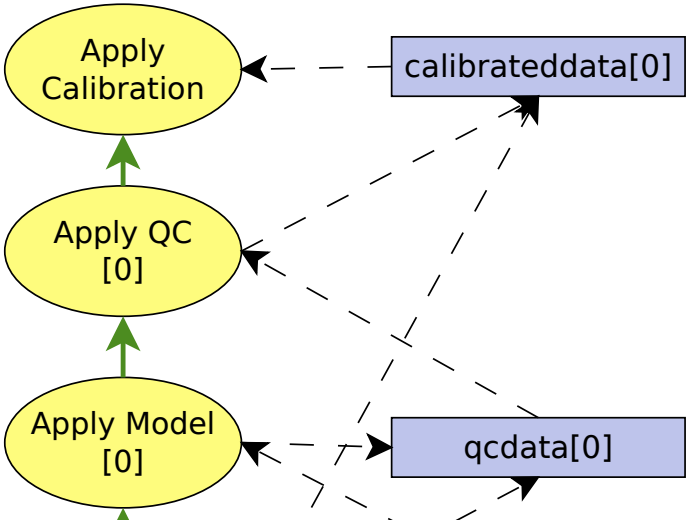



Complete process provenance (Data Derivation Graph)

- Automatically records detailed process execution history
  - data creations and modifications
  - step execution sequences
- Extracts process state at any given point
- **Undo**: The provenance overrides the current state with the retrieved state, and drives the process.

# Using the DDG to Undo




## The Scenario

- The scientist decides to apply another model.

Our system will

- present the user with a visualization of the DDG.

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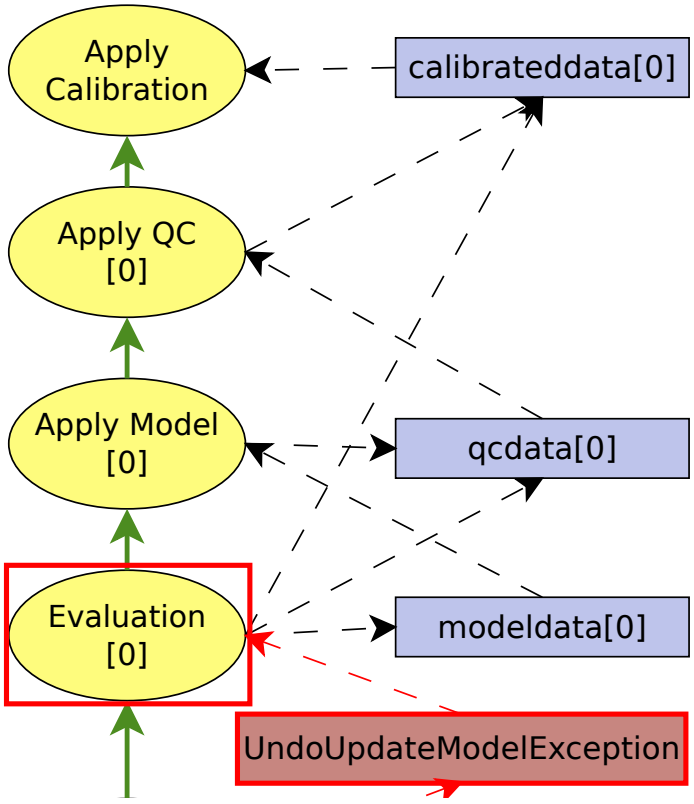


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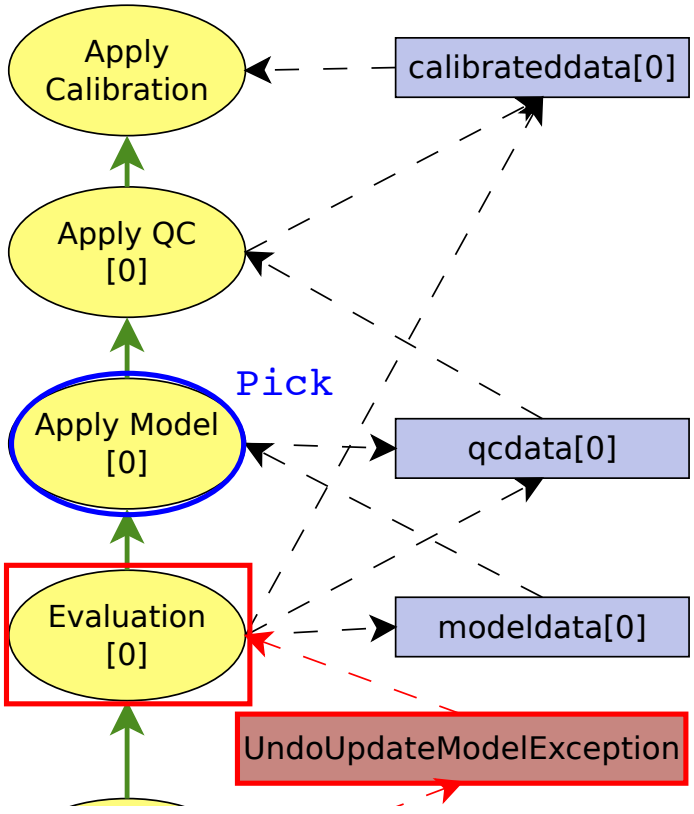


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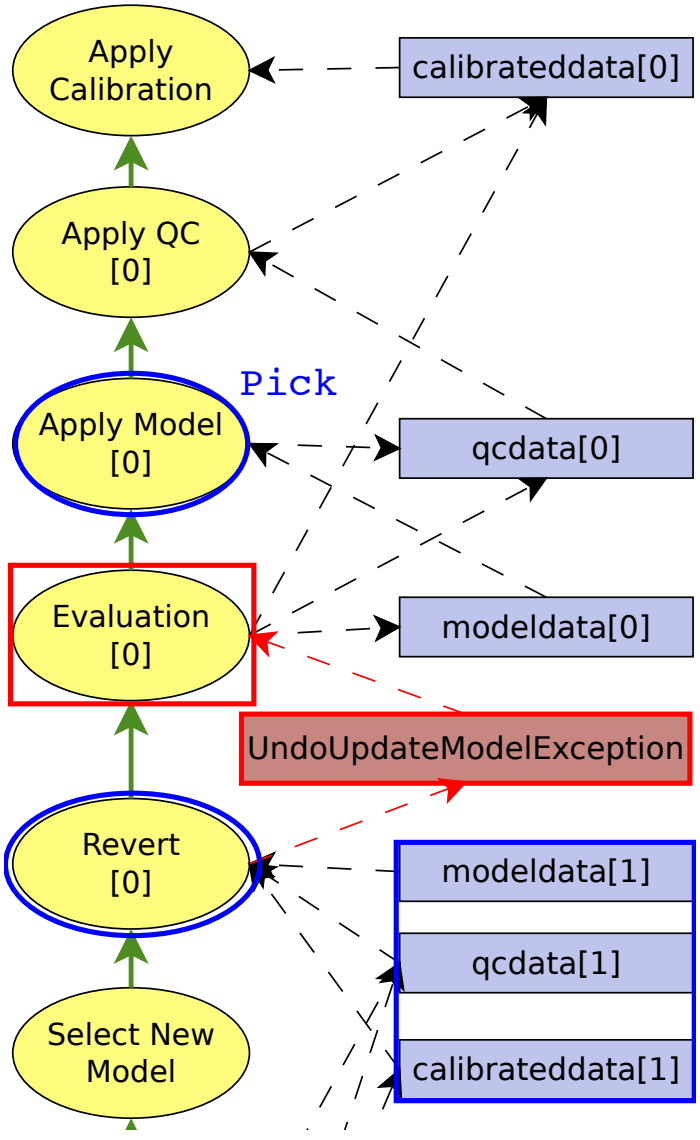


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- retrieve the appropriate execution state the scientist picks

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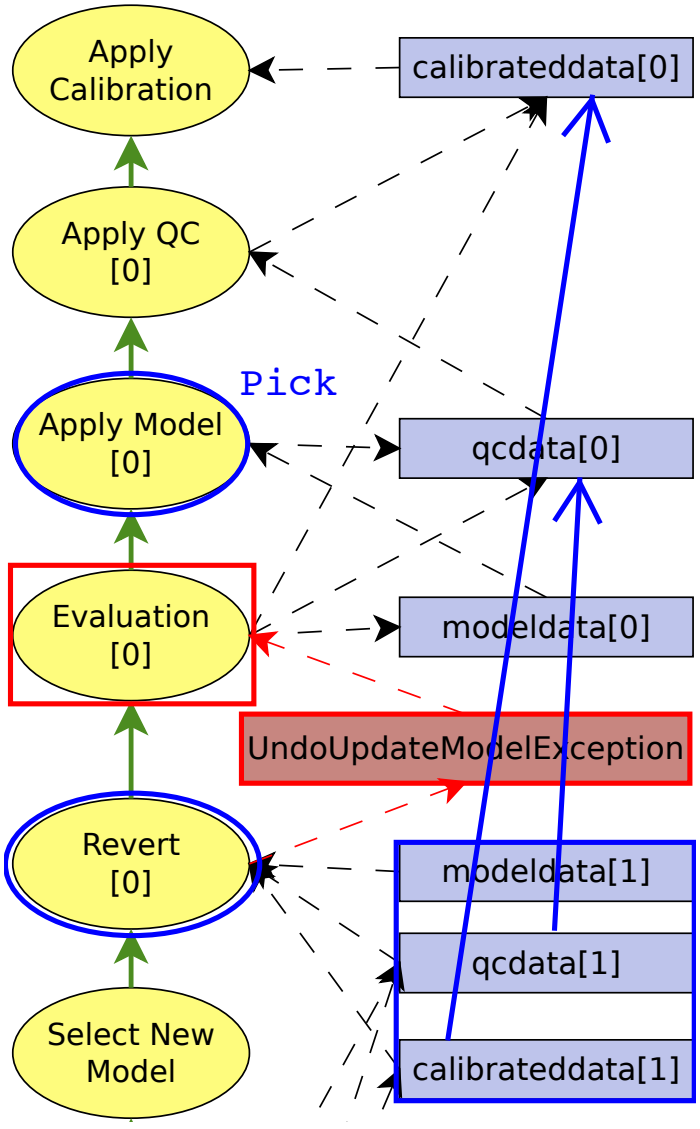


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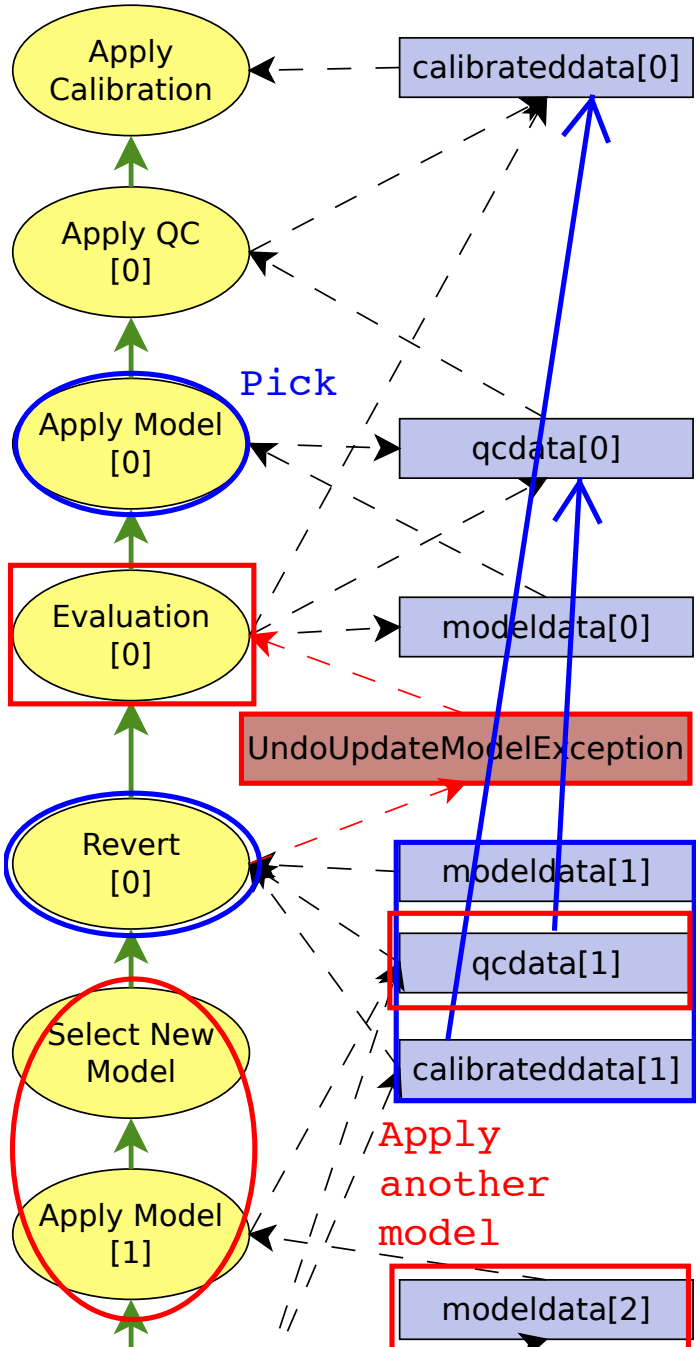


## The Scenario

- The scientist decides to apply another model.

Our system will

- present the user with a visualization of the DDG
- retrieve the appropriate execution state the scientist picks
- output the execution state vector and override the current state of the process.

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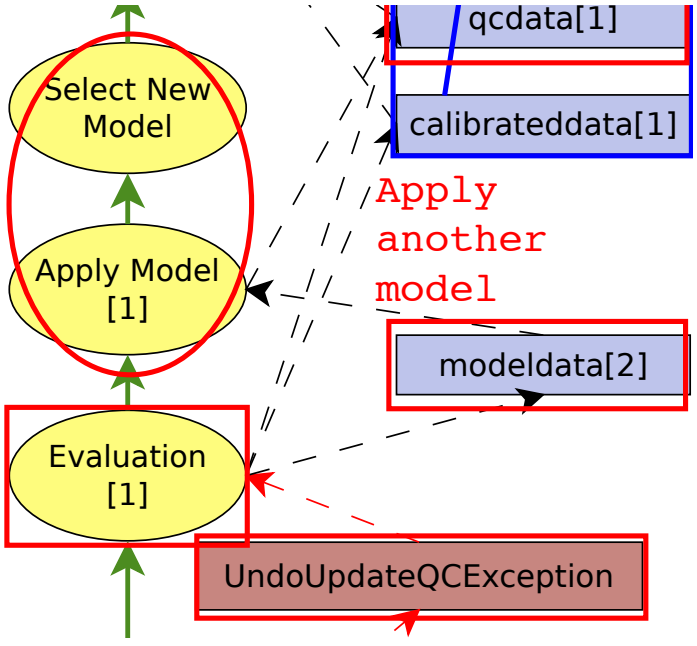


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- The scientist decides to apply another model.
- New model applied, evaluation suggests the quality control procedure needs to be reverted.

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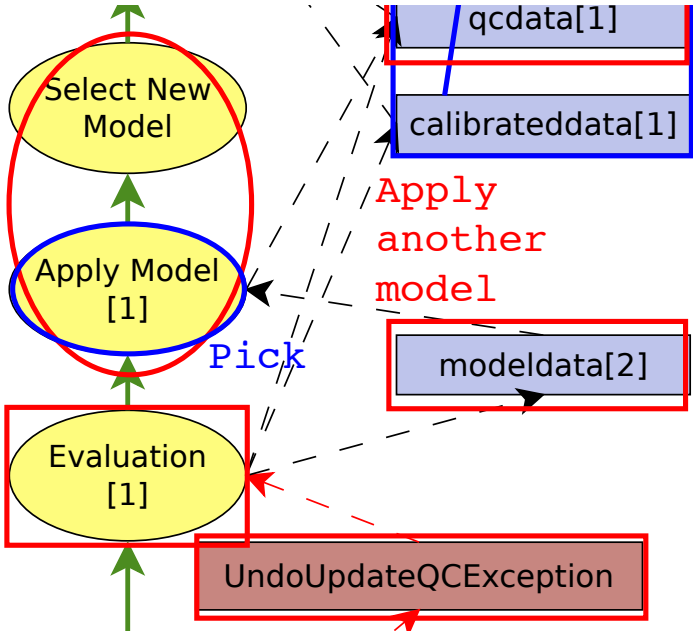


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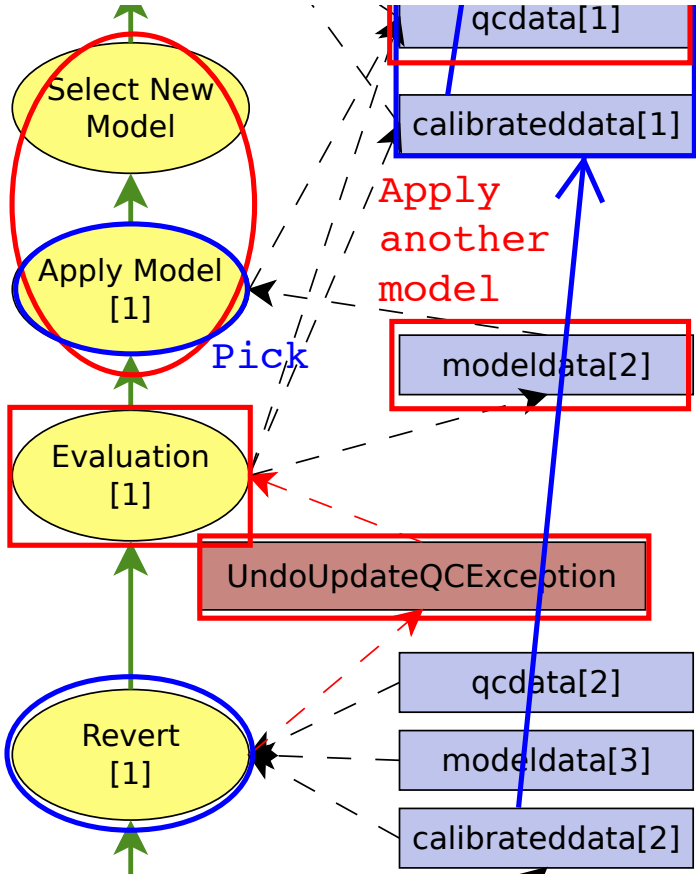


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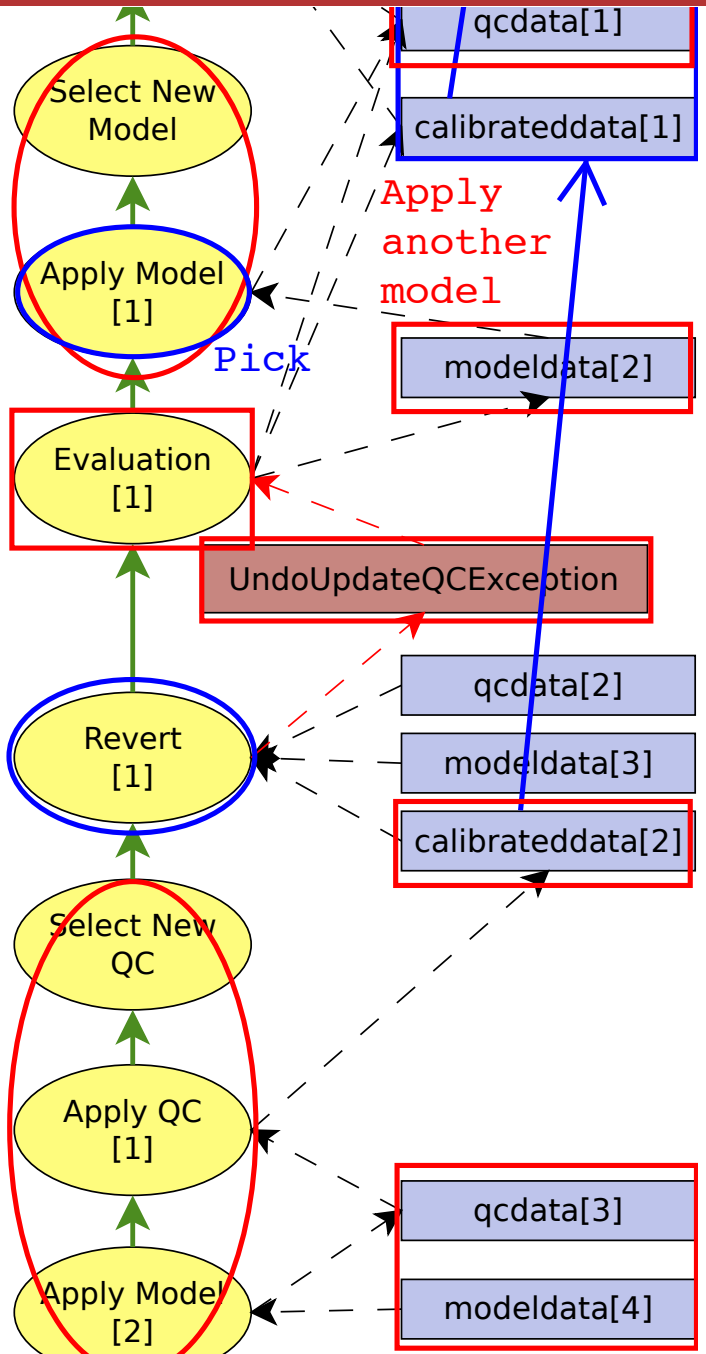


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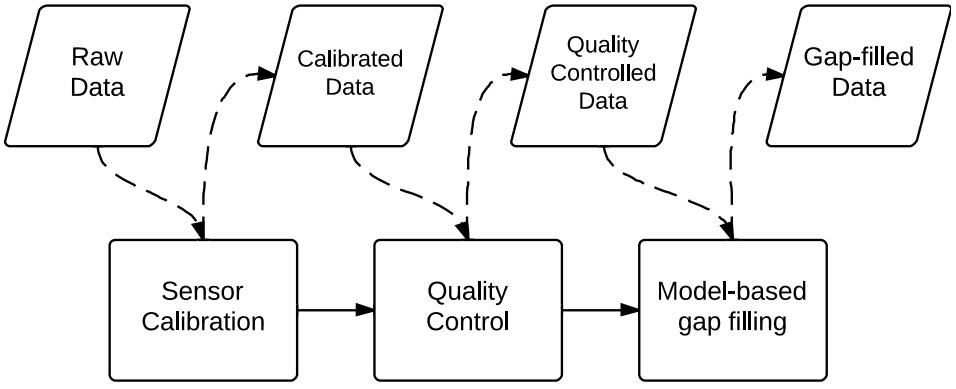
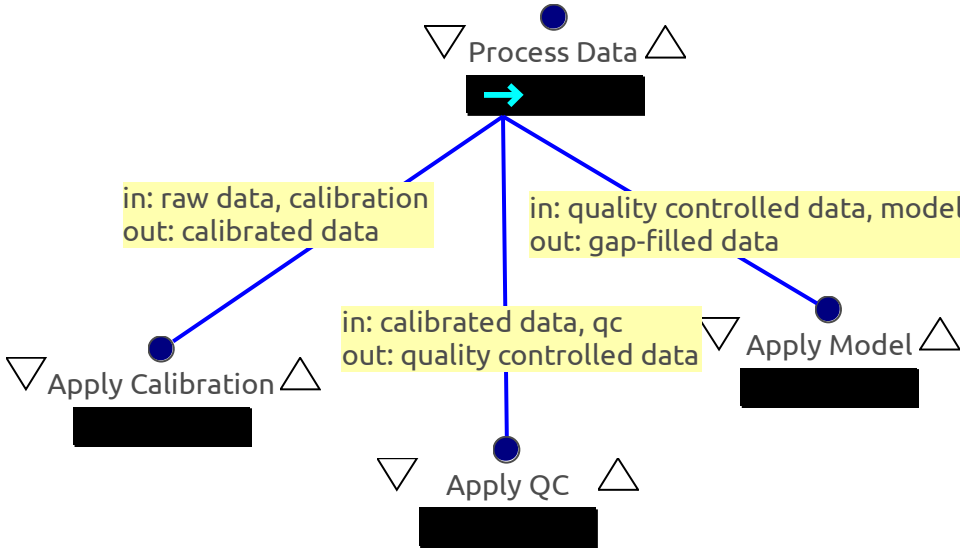
# Process Support for Undo/Redo




A detailed model of the process (using Little-JIL)

- guides the scientist in undoing and redoing previously executed work in the new context
- allows for tracking & examining the history as the scientist executes it
- manages dataflow and control flow in undo and redo
  - **Undo**: Identify a previously executed step and invoke `Revert`
  - **Redo**: Restore artifact values to previously executed step's values

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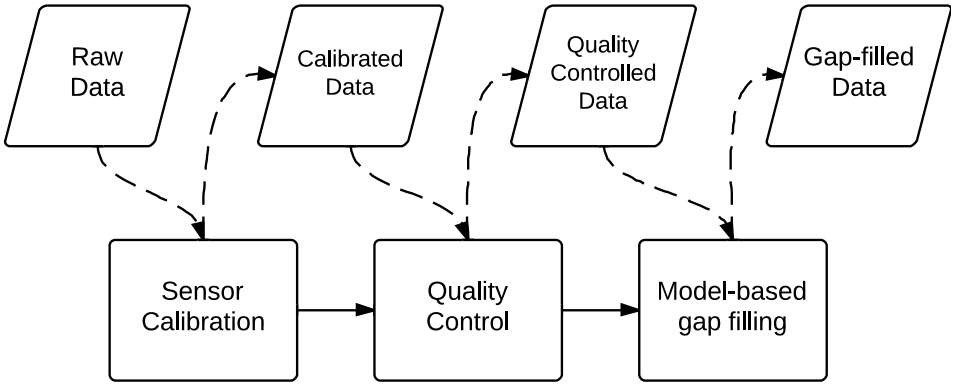


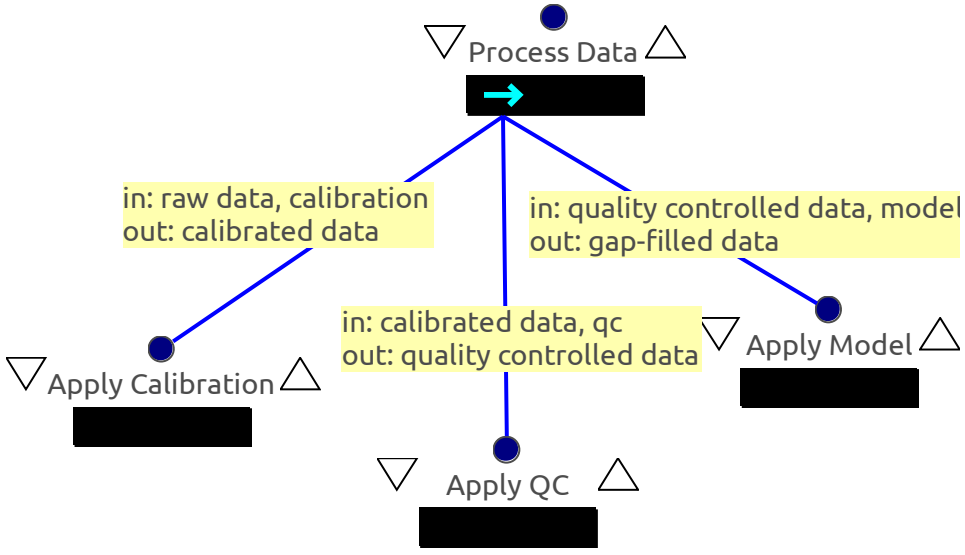


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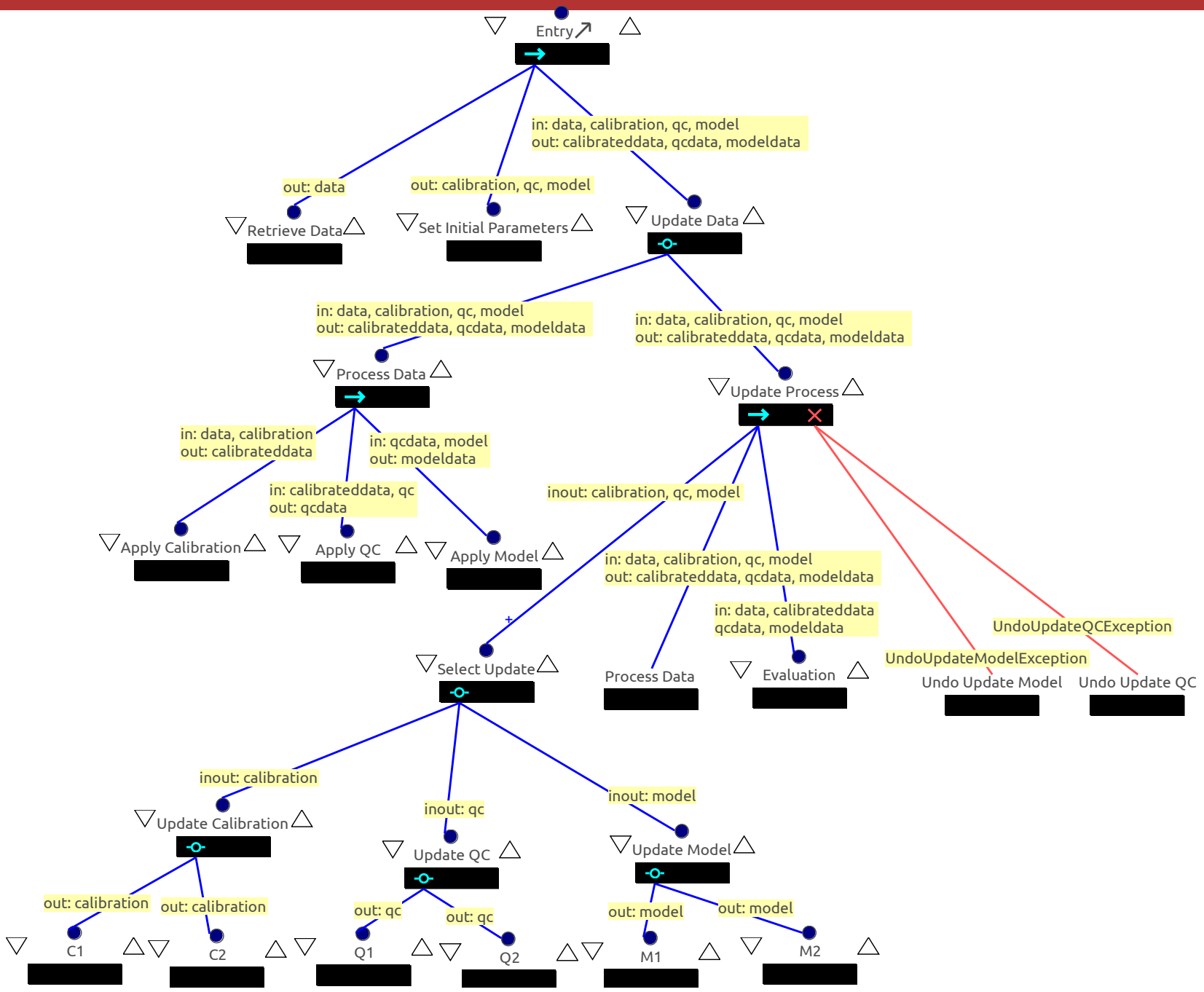
**The scientist needs to design the process beforehand**

# Complete Scientific Data Processing Process Definition



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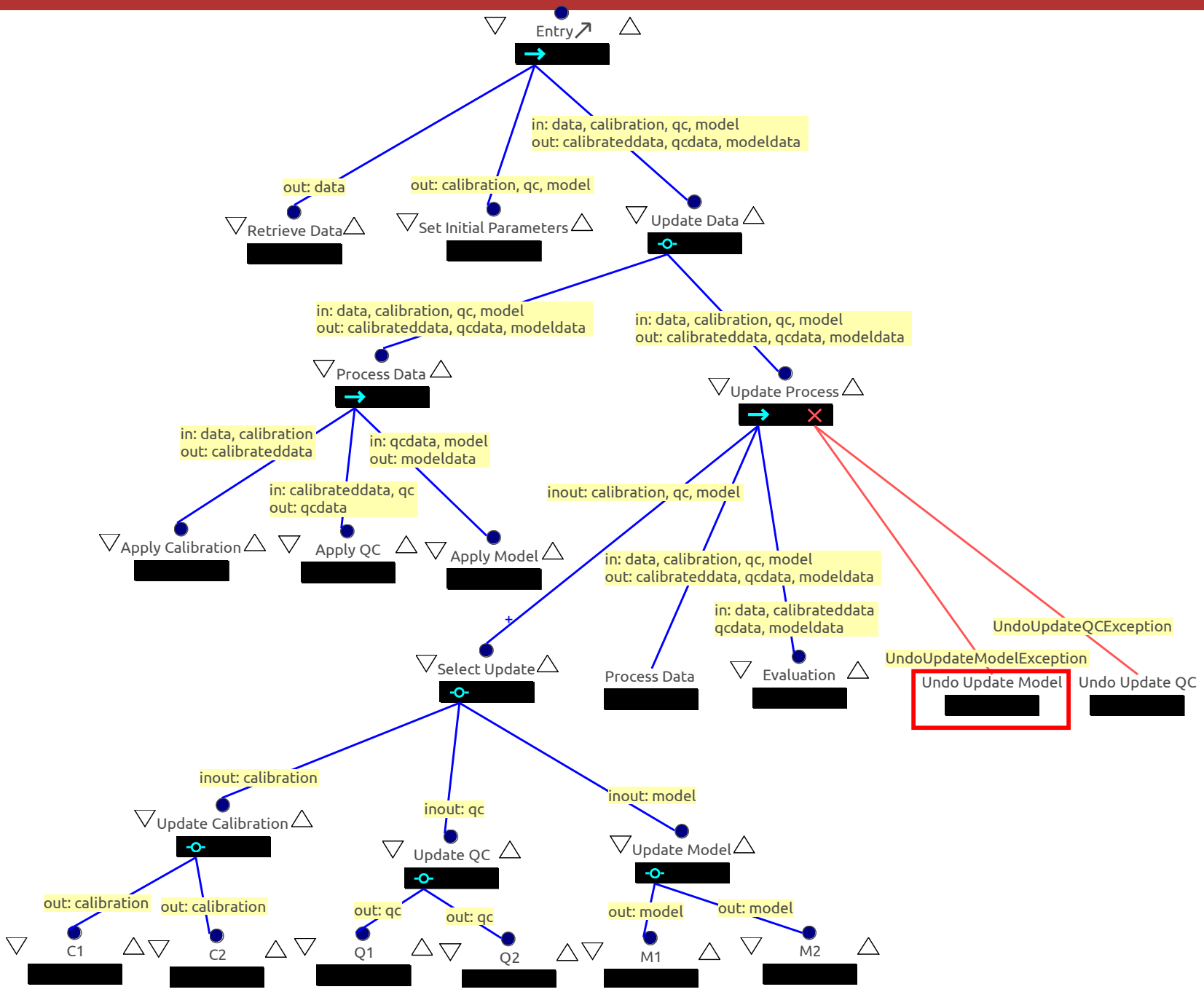
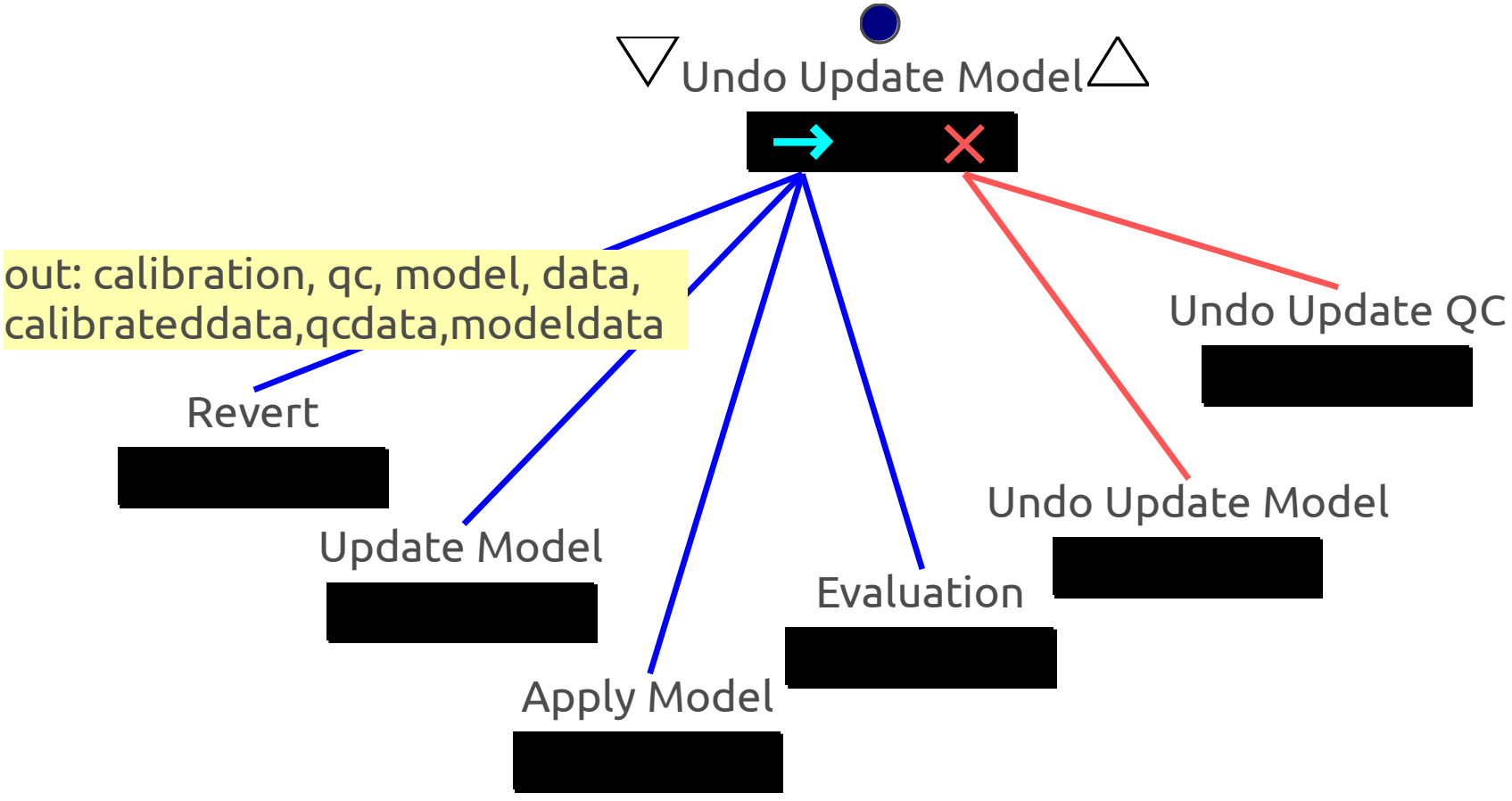


# Undo Update Model Step Elaboration




- `Revert` step retrieves the execution state vector at a selected point.

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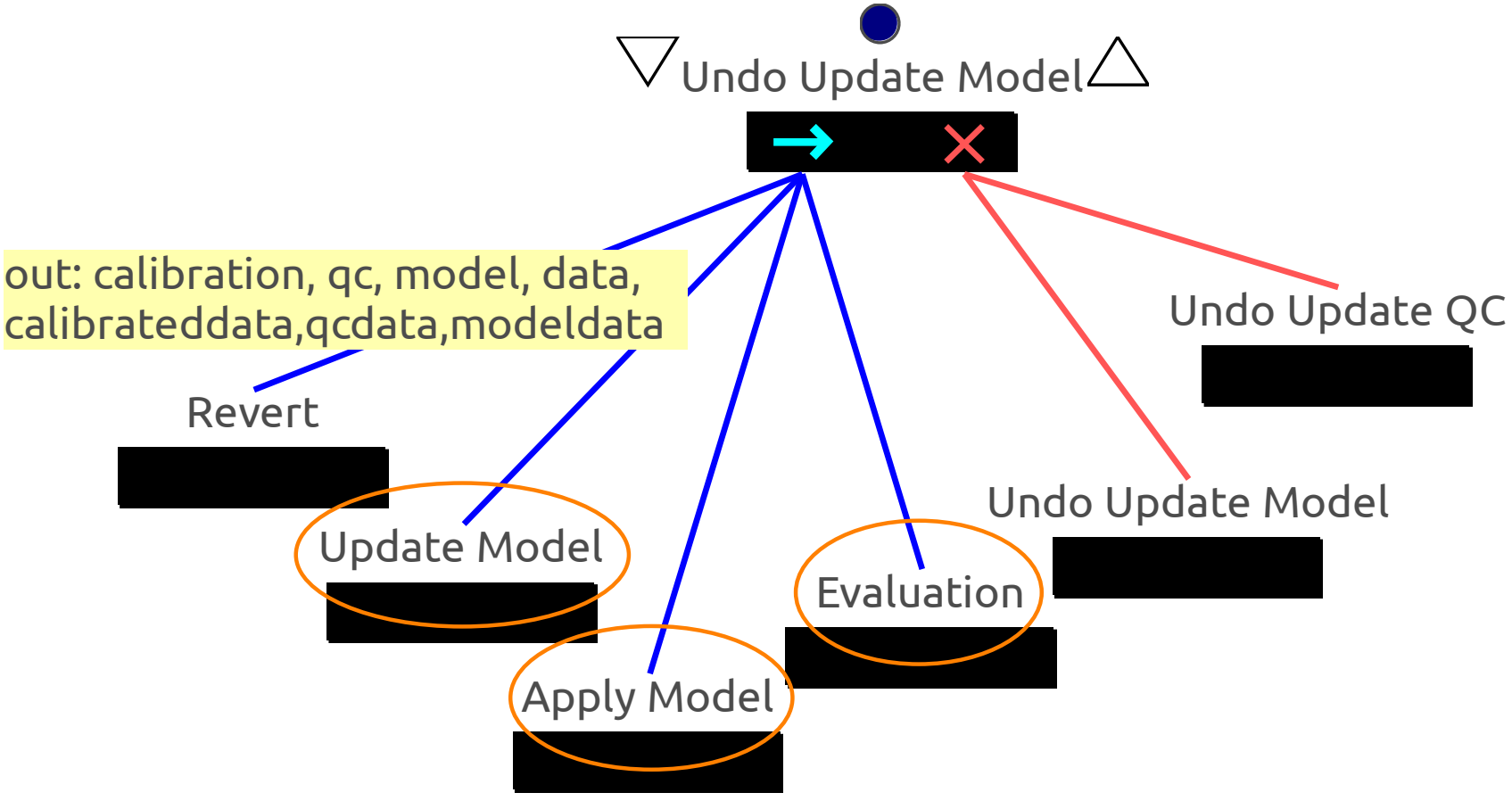
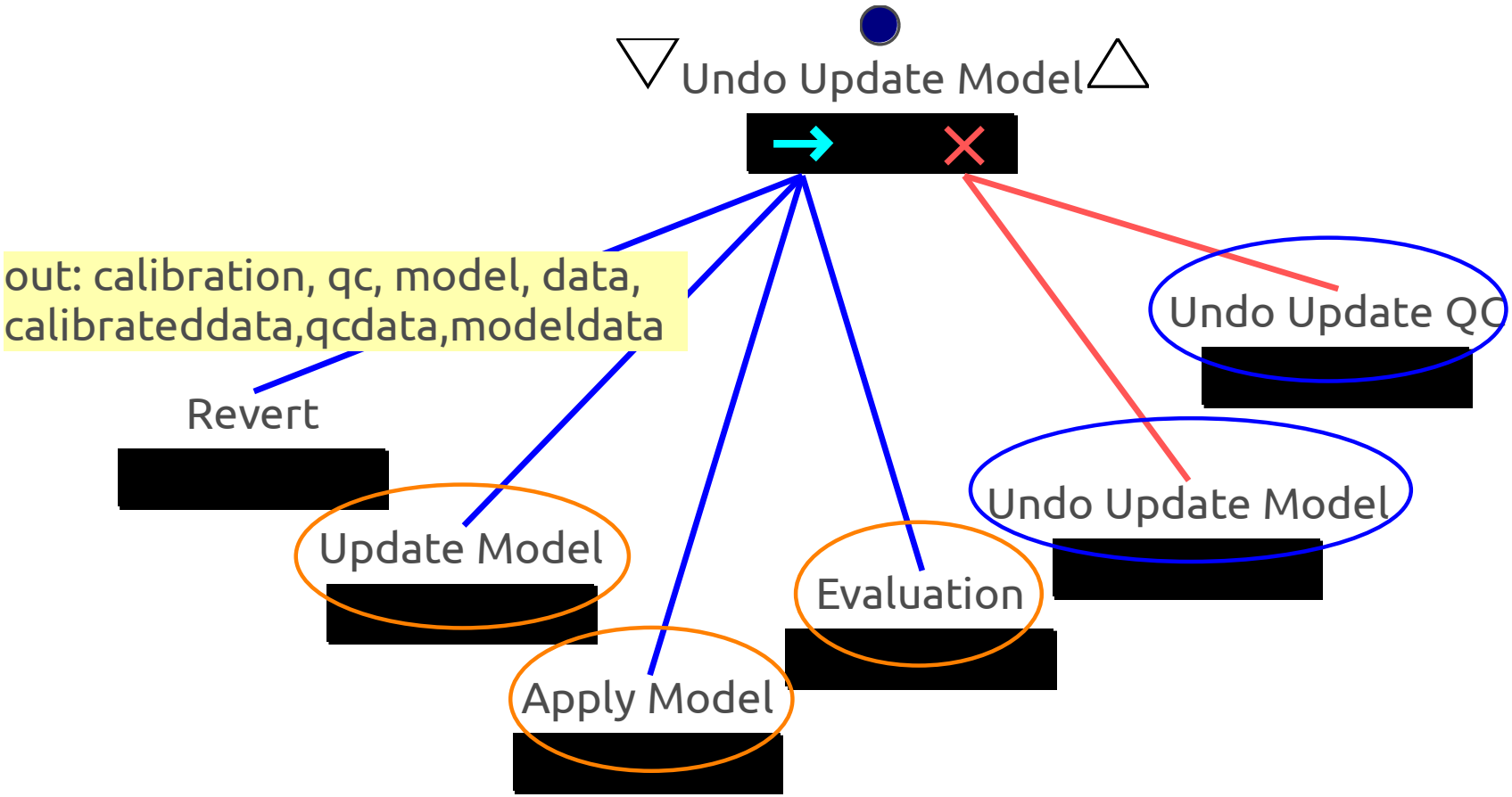



- `Revert` step retrieves the execution state vector at a selected point.
- `Update Model` step is redone, followed by another `Evaluation`.

# Undo Update Model Step Elaboration

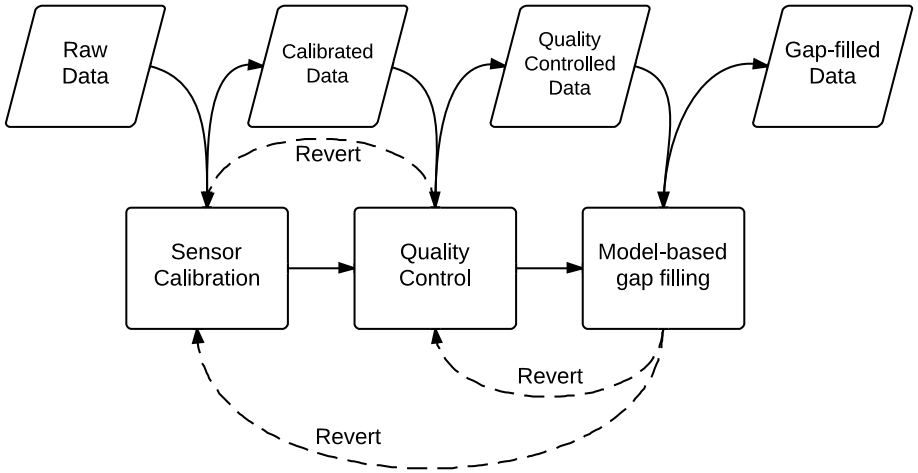


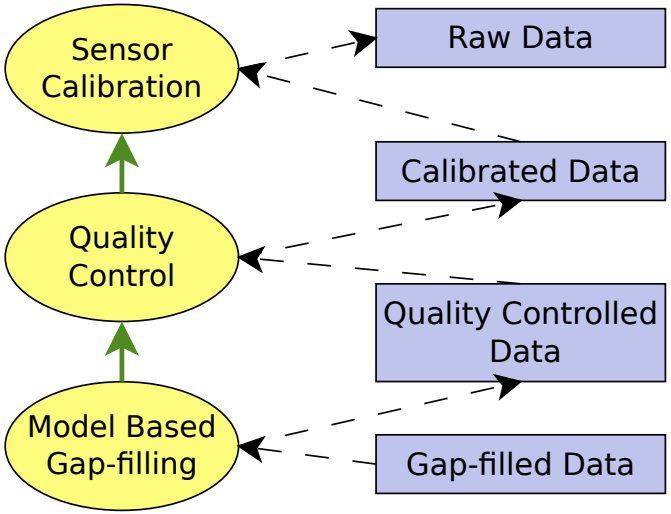

- `Revert` step retrieves the execution state vector at a selected point.
- `Update Model` step is redone, followed by another `Evaluation`.
- Exception handlers can be recursive to assist repetitive undo/redo.

# Related Work

- Provenance Visualization
  - Provenance Map Orbiter[Seltzer et al. TaPP '11] captures large provenance graphs and provides navigation mechanism.
  - Navigation model for scientific provenance[Anand et al. WORKS '09].
  - *DDG takes advantage of Little-JIL's hierarchical structure*
- Undo Mechanism
  - [Leeman TPLS '86] proposed a formal approach to undo operations.
  - Selective undo model [Berlage TCHI '94] provides the user with the ability to undo an arbitrary operation in history.
  - *Our approach takes into account both control flow and data flow*
- Undo in WFMSs
  - Kepler tolerates faults by providing check-pointing and forward recovery [Mouallem et al. SSDBM '10].
  - Self-healing Kepler (periodically constructing checkpoints) [Hary et al. HPDC '10].
  - *Our approach is complementary and allows undoing work and trying a different strategy when the results are unsatisfactory*

# Contributions and Future Work




**Contributions**:

- Undo tasks while remembering old artifacts and consequences
- Modify a data-processing step without losing the history
- Automatically redo set-aside tasks that are consistent with the modification

Our approach is implemented as a command-line tool.

**Future Work**:

- User interface for browsing and querying the DDG
- Detect conflicts in redo operations