An Operational Exploration of the Time Paradox

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The paradox of time has long troubled philosophy because time is simultaneously obvious in experience yet difficult to define. Augustine observed that we seem to understand time intuitively until we are asked to explain it. Heraclitus illustrated the problem through the image of the river that persists even as its waters continually change. Parmenides and Zeno exposed the confusion that follows when motion and change are forced into static categories of being. Einstein later provided a powerful formal representation in which events could be described geometrically as spacetime and worldlines.

A common thread runs through these perspectives; i.e., confusion arises when we fail to distinguish between things that exist, events that happen, and the representations used to describe those happenings.

Contemporary informational approaches add a further insight. ***Occurrences matter because they leave records.*** The effects of previous interactions are carried forward into the present condition of a system. The past persists operationally because its consequences remain encoded in the current state. (Aircraft con trails?)

Functional System models as state transition catalogues.

FSM[1] can be understood as a practical exploration of this distinction. In FRAM, the system exists as a current configuration of interacting functions, resources, controls and metadata values. FMI cycles happen as state-transition events that update those states. The spreadsheet, metadata structures and archived run records represent those states and transitions.

The FMI does not need to replay the entire past in order to determine the next state. What matters are the current values of coupled upstream outputs and metadata at the moment they are demanded. Temporal effects such as degradation, depletion, accumulation, fatigue, queue growth or resource exhaustion are therefore represented as current state variables. The relevant consequences of previous cycles are carried forward into the present state of the model.

[1] https://www.linkedin.com/pulse/toward-executable-modelling-emergence-david-slater-cqxye/

In this sense, FRAM becomes operationally Markovian. The next state depends upon the current state, provided that the current state contains the relevant effects of the past.

Implementation

This logic leads directly to the proposed FSM recording architecture, implemented as an Excel add-in - FRAIXL[2] . Each modelling run preserves two linked records. The first is the model record, which defines the system itself: its functions, aspects, metadata, equations, assumptions, live-feed mappings and initial state at T=0. The second is the instantiation record, which captures what happens when the model is executed by the FMI.

Because FMV/FMI already controls the cycling process and updates the metadata table during execution, when an exit function is activated, we can archive the completed whole-system metadata table as a frozen values-only run record. Each run is linked to a unique Run_ID, together with the associated model version, scenario and timestamp. Successive runs create successive archived records rather than overwriting previous states.

The archived record should contain the whole completed system state, not merely the exit function output. The analytically important evidence lies in the upstream function states, metadata values and coupled outputs that existed when the exit state was reached.

FRAIXL therefore separates execution from recording. FMV/FMI remains the execution engine responsible for cycling the model and propagating state changes. FRAIXL acts as the recording, recovery and analysis layer.

Applications

This recording architecture also creates several important future capabilities.

First, the accumulated archive of instantiation records becomes a source of learning and pattern recognition. Repeated runs allow comparison between normal, degraded and failed trajectories. Weak signals, recurrent precursors, instability patterns, delayed degradations and emergent resonance pathways may become visible only when many completed instantiations are compared. The archive therefore becomes a longitudinal behavioural record of how the model responds under differing conditions. Over time, this may support anomaly detection, weak-signal identification, clustering of operational states and machine-assisted pattern recognition across large populations of runs.

Second, the architecture naturally supports epistemic and active-inference-style digital twins. Because the archived records preserve both the predicted system state and the conditions under which that state evolved, the same structure can be used to compare parallel representations of the system. One record may represent the predicted or simulated state produced by the FRAIXL model, while another represents the observed or actual operational state derived from telemetry, live feeds or historical records. Differences between the predicted and observed trajectories become operationally meaningful. The twin is therefore not simply a visual replica of a system, but a continuously updated comparison between expectation and reality. The resulting discrepancies can be used for calibration, adaptation, anomaly detection and anticipatory reasoning.

[2] FRAIXL is the architectural workbench for recording, using and manipulating FRAM built system models.

Third, the archived state records provide the basis for immersive simulation and replay environments. Because each completed instantiation preserves the evolving functional state of the system, the records can act as a structured behavioural database for simulation engines, VR environments or synthetic training systems. In aviation, healthcare, industrial operations or emergency response, archived FRAIXL runs could be replayed, explored and manipulated interactively. The functional state records provide more than visual replay; they preserve the underlying causal and operational conditions that existed during the simulation. This creates the possibility of explainable and dynamically modifiable simulations in which users can observe not only what happened, but why particular states emerged and how alternative interventions might have altered the trajectory.

The result is a practical and philosophically coherent treatment of time within complex system modelling. The system exists as a present configuration of interacting functions. FMI cycles happen as state-transition events. The spreadsheet, metadata and archived run records represent those states and transitions. The paradox of time is thus reduced when we stop confusing things, happenings, records and the models we use to describe them.

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