Context x Goal (CxG) modelling levels for actor activity

1 Introduction

The general framework for modelling actor activity is presented in (Brézillon, 2026), we give here only few characteristics. There are four modelling levels: (1) the conceptual level where ideas are stated on the basis of concepts of interest for modelling an activity, (2) the operational level where ideas are formalised in a mental model, thanks to a relevant context-based formalism of representation, (3) the implementation level where mental representation of the actor is expressed in a contextual graph from where is extracted the mental model as a path and (4) the environment level where the model, first, interacts with the activity environment (and mainly actor as source of context), and, second, from where contextual elements are instantiated when needed from the four context sources. In this framework, the activity model exists jointly at the operational level (actor's understanding of the activity as a mental model) and at the implementation level (a sharable understanding of the activity development in its environment as a path in a contextual graph), while the fourth level concerns environment. Operational and implementation levels represent two views on actor's experience (as mental representation and as contextual graph) on the development of a mental model from the mental representation.

2 Conceptual level

The conceptual level concerns the concepts "activity", "reasoning", "context", "contextual element" and "experience", these concepts of interest being not (at least totally) formalised. Our goal is to propose a formalisation of "context" in order to have an efficient formalism for modelling the other concepts of interest. We adhere to the definition of Sarrazin et al. (1996): "an activity is the (physical and mental) behaviour that an actor exhibits for realising a task". The notion of activity encompasses that of "task realisation" including actor that accomplishes the task. Modelling an activity involves modelling reasoning to justify the move from a step to the next one. As a consequence, an actor apprehends an activity through a mental model including its development (reasoning steps with processes and decision holds at each move between steps). At the end of each activity step, the next step is chosen by either a deductive (i.e. sequential) reasoning or contextual knowledge if there are alternatives.

Decision-making, as an operational representation of reasoning, often is described as the process of collecting, assembling and structuring the relevant knowledge and information to contextualise the decision for action. Reasoning is a cognitive process that underlies and guides the activity, and the actor is part of the context-based modelling loop.

Context allows distinguishing contextual knowledge and external knowledge concerning activity development. Contextual knowledge is the set of elements related in a flat way to activity development, while external knowledge concerns elements of the context that are not important for the actor's focus at hand. Context changing during activity development, the frontier between the two types of knowledge is porous. An element of contextual knowledge can become external if it is no more of interest, and, conversely, an element of external knowledge can become contextual because considered for the development of the activity.

3 Operational level

The concepts chosen at the conceptual level acquire an efficient expression though a context-based formalism at the operational level. We also retained from Cognitive Sciences the notions of mental representation and mental models, but with a different interpretation on the relationships between them. An activity is more than a task model, because it integrates how the task is realised and actor's reasoning held. The context-based formalism provides an expression of actor's experience as a mental representation that brings together all activity developed in different contexts. For simplifying the introduction of context from different sources in activity modelling, we assimilate context to a set of contextual elements. A mental model is an internal representation of external reality (Craik, 1943) to anticipate events, and mental representation accumulates mental models obtained in different contexts. An actor, facing a known activity, does not seek to have a global picture of the activity but wants to follow step-by-step the reasoning to detect if all elementary decisions were justified in the context at hand or how a reasoning step must be changed.

The actor develops a mental model based on identification of the relevant contextual elements and the recovery of their instantiations in the context at hand. Identification and instantiation of contextual elements are parts of reasoning from one step to the next one. This step-by-step evolution of the activity produces an ordered sequence of instantiated contextual elements that we call hereafter the proceduralised context. Proceduralised-context building, first part of decision-making, concerns the gathering, assembling and structuring of instantiated contextual elements. The proceduralised context expresses a real-time context, which evolves jointly with the mental model development.

4 Implementation level

Mental model and mental representation correspond to a qualitative modelling that makes sense mainly for the actor but need to be implemented to be confront to the environment and shared with others. The CxG formalism allows a uniform representation of knowledge, reasoning and context for describing an activity as a process, not as object (Brézillon, 2023). A contextual element is implemented as a pair of contextual and recombination nodes (Brézillon et al. 2000). This definition has a deep impact on the power of the CxG formalism. Figure 1 shows the four components of the CxG formalism that are action, contextual element, activity, and Executive Structure of Independent Activities (ESIA).

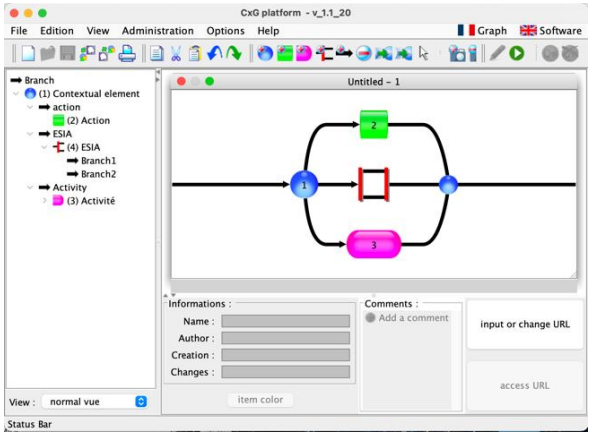

Figure 1 Components of CxG formalism in the CxG software

An action (the green square) is the elementary component of the activity. Contextual elements (the blue circles) are described just below. An activity (pink elongated oval) is a

contextual subgraph that may appear on several paths in the global contextual graph or introduced by the actor for different types of knowledge. An Executive Structure of Independent Activities (ESIA, the vertical red bars) avoids the introduction of an artificial complexity in the representation for a local goal. The order for executing independent activities in an ESIA does not matter (activities can be executed in parallel too), but both independent activities must be executed before to continue the crossing of the contextual graph. An ESIA also is assimilated to a building block of the CxG formalism, like an action or an activity, because its content is isolated of the rest of the activity described in the contextual graph.

CxG software[1] is currently written in Java under GNU Public License and contextual graphs are stored in XML for a reuse in other applications. Software design and development was user-centred for an intuitive use by nonspecialists in computer science and mathematics (see Brézillon, 2026) for an extended presentation). A contextual graph integrates mental models because two mental models generally differ by only different instantiations of an existing contextual element that do not affect the structure of the contextual graph, or by an additional contextual element in one mental model by simple accommodation.

The implementation of a contextual element as a pair of contextual and recombination nodes in the contextual graph offers functions that enlarge the operational nature of the modelling:

- There are as many exclusive branches between a pair of nodes as instantiations of the contextual element.
- Instantiations are provided from sources of context at the environment level.
- Each branch corresponds to an expression of the reasoning step associated with the instantiation and makes the mental model unique.
- contextual elements and instantiations must be managed separately.
- Two contextual elements are either independent or one is on a branch of the other. It gives to contextual graphs a series-parallel structure.

5 Environment level

The immediate environment of an activity is all that is not in the activity but constrains its development. The two elements at this level are the sources of context and the instantiation of a contextual element. The four sources come from the actor, the activity, the situation and the available resources needed in the local environment. They provide in routine the instantiations for contextual elements on the path followed by the reasoning in the contextual graph. Actors play a central role in activity modelling because knowledge in a contextual graph is mental representation and experience of the actor. Moreover, the actor is responsible for fixing unexpected situations. First, the mental model is correct, but its context is new for the actor and thus not in the contextual graph. Second, a contextual element is missing in the model because it kept the same instantiation in all previous contexts (the constant instantiation is integrated in the activity before the development). Third, the activity must be performed in a radically different context that requires an extension of the activity model.

[1] The software is available freely from the author on simple request.

For efficient decision-making, actors seek first to identify the context at hand to determine the sequence of actions to realise and act rapidly. The context of a mental model can be analysed by unfolding the proceduralized context, and the “what to do” is provided by the list of actions to execute.