Designing Interactions for Smart Objects with Flows

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Abstract
A flow is a collection of sequential actions glued together with a plan to attain an objective. Due to its intrinsic properties of state-fullness, consistency, temporal and spatial dependency, a flow offers opportunistic optimizations in modeling adaptive user interaction. This is particularly important for interaction with smart objects designed for providing ambient guidance through intelligible feedback. In this position paper, we present the background of flow driven interaction and our early explorations of a couple of research issues: i) A Flow driven Interaction Framework and ii) Designing Intelligible Feedback with Flows.

Keywords
Smart Object, Work Flow, Interaction

ACM Classification Keywords
H.5.2 User Interfaces: Interaction styles

Introduction
Classical human computer interaction is framed against a dynamic transfer function that couples input and output through a feedback loop [1]. More recently as a natural consequence of engraving computation in the fabrics of environment, this input space is enhanced with richer modalities like situational contexts of

humans (e.g., location, activity, etc.) to modulate system outputs, and to improve the dynamics of interaction by providing services proactively [3]. Context driven systems usually consider temporal contexts, and in some cases (for systems with learning capabilities) historical contexts to model the interaction. However these systems usually do not predict the upcoming aspects of context beyond current interaction point. As a consequence, they are not adequate in providing effective guideline, and adapting interfaces over time by looking probable user activities and associated interaction points ahead of the execution. In addition context driven systems are specifically framed for supporting a particular activity. However, human activities are often interleaved, and very much ad-hoc even in a controlled environment. Thus, rule based systems driven by contexts provide limited opportunities to maintain the interface consistency for supporting such interleaved interactions. The notion of flow can contribute to address these issues. A flow is a collection of sequential actions stitched together with a plan, where each action is interdependent and might offer one or more interaction opportunities. This essentially means a flow enable an action and it's associated interaction points to be analyzed, modeled, and adapted ahead of the execution. Specifically, interaction driven by flows brings three optimizations, these are:

- A flow enables a system to provide intelligible feedback by considering not only the present and historical context, but also future planning. This essentially enables a system to guide its user to perform the activities according to the flow. For prescriptive system, a flow driven interaction can thus provide appropriate feedback to user when his/her activities deviate from the actual plan and can guide the user. However for a descriptive system where activities are typically modeled in an ad-hoc fashion, a flow may offer support in a more opportunistic fashion.
- A flow models a collection of activities that are performed over time. However, due to the awareness of the entire activity space, a flow can optimize the upcoming interaction points (both immediate and later) based on the current and previous interaction patterns. This means, it provides an interface designer with the flexibility to adapt future interface references.
- A flow is particularly useful to maintain the consistency of the interfaces of interaction points. Usually, human activities are interleaved, and two consecutive human tasks may be part of two different activities with different goals. Having a flow associated with an interface, allows designers to ensure that the consistency of the interface is maintained over time, when human actions are switched from one activity to another.

We are currently exploring whether the concept of workflow (or simply flows) can be applied to model interactions in a pervasive computing environment. In this position paper, we give an overview of flow and its implications in modeling the interaction within a dynamic pervasive computing environment.

Flow Driven Interaction

To have a formidable understanding of flow and its implication in the interaction design in this section we first give an overview of flow, its types and

combinations in the context of pervasive computing environment.

Notion and Categorization

The notion of flow or more generally workflow has a rich history in the organizational management in respect to business process automation. A workflow is a depiction of a sequence of operations; declared as work of a person, work of a simple or complex mechanism, work of a group of persons, work of an organization of staff, or machines. Workflow may be seen as any abstraction of real work, segregated in work share, work split or whatever types of ordering[1]. We have adopted the classical concept of workflow and normalized it to apply in the context of design of pervasive computing interaction.

"A flow is a sequential model that consists of a set of actions, stitched together by a plan that specifies how the actions should be performed to achieve a goal under certain constrains. In other words, a flow formalizes and maps our activities to certain tasks to achieve a goal [2]."

Flows are situated in real world and are logically associated to real world entities. In the context of pervasive computing environment, a flow can be of different types considering its association as depicted in figure 1.

1. **Personal Flow:** A personal flow is attached to a person and models the sequence of activities a person needs to perform to attain a specific goal (Figure 1(a)).

[1] http://en.wikipedia.org/wiki/Workflow

2. **Object Flow:** An object flow is attached to a smart object and models the sequence of states that the object possesses in supporting a personal flow (Figure 1(b)). An object flow can be part of a personal workflow and represents state of actions for one or multiple tasks as shown in figure 1(d).

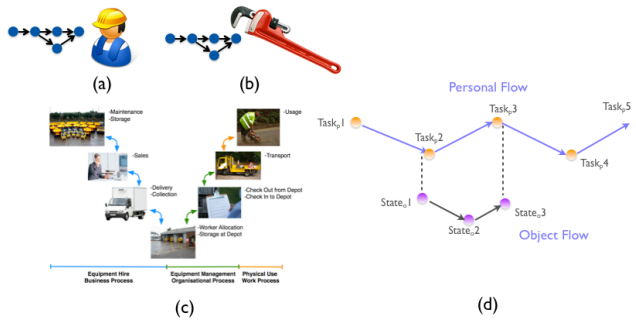

Figure 1: Categorization of Flow. (a) Personal Flow, (b) Object Flow and (c) Organization Flow

3. **Organizational Flow:** An organizational flow is associated with an organization and models the sequence of business and work processes according to organizational norms, hierarchy and policies to attain an organizational objective (Figure 1(c)). An organizational flow can be composed of multiple personal and object flows.

Combination of Flow Driven Interaction

In the previous section, we have described three different kinds of flows associated in a pervasive computing environment. The organization flow represents the multiplexed version of personal and object flows. One way to characterize the interactions driven by these flows is by looking at ways in which

these flows coupled together to interact in a pervasive computing setup. In the following we describe four different interaction use cases combining these flows.

1. Figure 2(a) depicts the first case primarily driven by a personal flow. A person carries one or multiple flows that describe the sequence of activities that the person needs to perform to achieve the goals. When a person reaches a point in its flow where he/she needs to interact with an object, personal flow can interact with the respective objects to create a dynamic coupling enabling the object to support the activities within the flow to advance to the next course of actions towards achieving the objective.
2. Figure 2(b) highlights a variant of case 1, where physical objects are populated with one or multiple object flows that can support personal flows or organizational flows. However, in this case, a person do not possess any flow, but at the point of interaction (i.e., when the object is used by the person) the object flow is associated with the person and according to the activities performed by the person, the object flow is advanced to the next course of its state.
3. Figure 2(c) depicts the conjugal of the above two use cases, a person may carry one or multiple workflows, and at a certain point of his/her activities he/she might reach a situation where he/she needs to interact with one or multiple objects populated with one or multiple object flows. In this case, two flows are merged; ideally, the object flow becomes a sub-flow of the personal flow. However, in the case when the object flow represents a part of a larger organizational flow, the personal flow coupled with the object flow can become the sub-flow of the larger organizational flow.

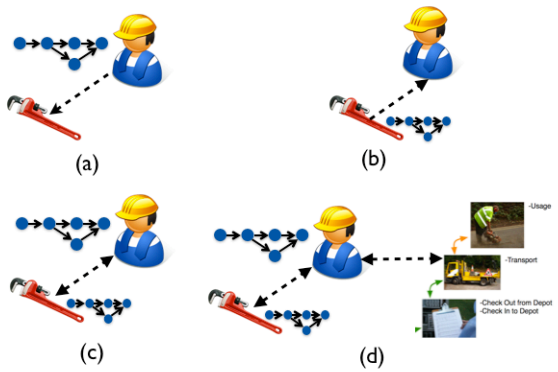

Figure 2: Combination of Flow Driven Interaction

4. The final case is the auxiliary flow driven by the coupling between personal and object flows as shown in figure 2(d). In this case, the auxiliary flow depends on the interaction between the personal and object flow and based on the transition of their interaction, the auxiliary flow is advanced to next stage to meet its objective.

Research Issues

In the previous sections we have provided a concise overview of flow and the interaction use cases driven by flow. In this section, we look at two prospective research issues.

Interaction Framework for Flow driven Interactions

In the introduction, we have mentioned that flow brings several optimizations to interaction design. However, to

elevate experiences, it is imperative that a concrete guidance on the process of designing flow driven interaction is needed. One way to address this is to provide an interaction framework, divided into multiple layers that separate the atomic activities involved in a flow driven interaction. In the following, we propose a simple Interaction Framework that is designed to handle specific needs of flow driven interactions.

The framework actually models a group of activities and ties them in a sequence to improve user's experiences in attaining his/her goal substantially. The framework is composed of 5 sequential steps as shown in Figure 3.

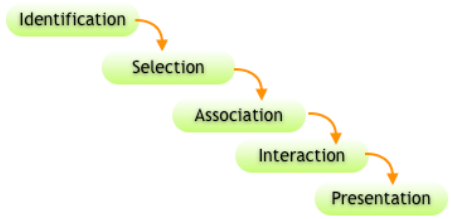

Figure 3: A 5-Step Interaction Framework for Modeling Flow Driven Interaction

1. **Identification:** Flows are situated in the real world, and their digital presence naturally brings the obvious question of how to discover the flows. This identification phase is designed to make a person aware of the flows available in the environment. This awareness should cover (but not limited to):

    - Awareness of available flows (Search/Browse).
    - Awareness of available activities (User Actions that can be performed to move the flows forwards).
    - Awareness of the Sate of Flows (state of object in a flow).
    - Awareness of the consequence of the action on the flow.

To support all these, an approximate solution could be to embed a flow browser in the space. Ideally this would be engraved in a natural interface, like projected interface with touch/gesture/voice based interaction.

2. **Selection:** This phase is to enable a person to select and focus on the appropriate flow, for a prescriptive system, this selection could be automated by understanding the context implicitly, e.g., activity. However for descriptive system it is useful to provide users with a space browser for selecting a flow.

3. **Association:** There could be multiple flows (personal, object and organizational) existing in the space simultaneously for a range of activities, persons, and organization. The association phase ensures that a flow is attached to the proper activity, and its constituents, i.e., objects, persons, and organization.

4. **Interaction:** This phase is the actual interaction phase that moves the flow forward. This interaction could be physical action or digital action and ideally should be captured implicitly via external sensory systems and machine learning techniques.

5. **Presentation:** This is the final phase where the classical feedback is brought into the loop. The presentation issues itself is an interesting research issue that we address next. In this phase, users activities are verified against the prescribed results in the flow. For prescriptive system, the feedback could be pushed to user when his/her activities deviate from the actual plan and can guide the user. However for a descriptive system this feedback presentation could be more opportunistic.

Designing Feedback for Flow driven Interactions

One of the distinguishing features that flow brings into interaction design is a work plan spaced over time which enables designer to look ahead of the interaction points. This is particularly important for providing effective guideline to user. In addition, any interaction requires an appropriate feedback for making sure that users are aware of their operations and capable of proceeding accordingly. In pervasive computing, feedback design is always critical as it requires finding a proper balance between perceptual complexity and information overload, making sure information is provided in an appropriate way, i.e. considering proper timing, location, identity, intuitiveness and other contextual attributes.

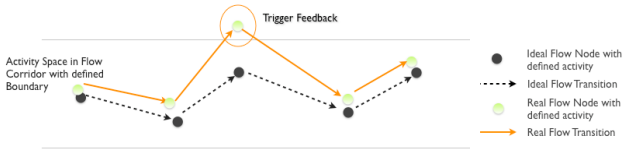

Figure 4: Flow Driven Feedback

Flow is an interesting addition to this context space. Due to its intrinsic properties of state-fullness, and distribution over time and space with constrains (boundary parameters), flow enables designing effective guideline and feedback for both prescriptive and descriptive systems. For example, figure 4 demonstrates a case where a flow defines the constrains over time and space and whenever actual users activities deviate from the boundary parameters, an appropriate notification is triggered for guiding user's next action. Since flow enables a designer to understand the next point of action, the notification/feedback can be designed considering not only present and historical movements but also upcoming interactions.

Conclusions

We have presented the background and early research explorations of flow driven interaction in pervasive computing environment particularly involving smart objects. We believe, our early experience will instigate stimulating discussion in the workshop and will help us to formulate some concrete research agendas towards flow driven interaction design.

References

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