Flow-driven Interactions for Adaptive Pervasive Applications

Bashar Altakrouri

Computing department
Lancaster University
Lancaster, UK
LA1 4WA
b.altakrouri@comp.lancs.ac.uk

Abstract: The era of ubiquitous and pervasive computing technology opens the world for new pervasive applications and services within the physical surroundings. Often users find themselves dealing and interacting with multiple applications simultaneously to achieve certain goals to satisfy certain motive. Currently, pervasive computing applications are individually created and tailored with little or no consideration of the users' overall goals and intentions. My research investigates the concept of flow-driven interactions as a prominent and innovative model for goal-driven activities carried out by users in the pervasive computing setup. Flow-driven interaction model is aimed at overcoming problems such as interaction consistency, losing orientation, context switching and interface adaptation, resulted from user interaction with multiple pervasive applications, devices and objects.

1 Problem Statement and Research Question

My research is investigating the impact of the flow concept on human interactions in pervasive computing applications. A flow is a sequence of goal-driven activities carried out to achieve certain motives.

Hypothesis: flow-driven interactions are naturally compatible with the adaptive and dynamic nature of pervasive computing applications; as such interactions adapt according to the environment and preserve the interaction consistency across multiple pervasive applications in the physical surroundings.

Applying this concept engages many important questions, three of which will be investigated in this research:

Question A

How the flow concept, and its logic, influences the user interactions in a pervasive setup?

Question B

How flow-driven interactions in pervasive applications differ from those with conventional interactions?

Question C

What are the qualities of flow-driven interactions in adaptive pervasive applications, how are they verified, and how do these influence its interface design?

2. Motivation

Pervasive computing technology envisions support to human users by embedding technology in objects, spaces, etc. Applying this resulted in a new generation of pervasive services and applications have become accessible throughout the physical surroundings.

Typically, in a pervasive computing environment users are challenged with new generations of pervasive interfaces and interaction techniques. Multiple services, functions and applications are accessible through multiple interfaces and devices. Moreover, pervasive computing applications are designed and implemented with no direct consideration to other applications within the same context and sphere of interest. Therefore, there is little or no consideration for the overall goal of the user's intention to interact with those applications.

This research considers people's involvement in multiple simultaneous activities to complete and satisfy goal-driven tasks. This involvement happens naturally through the course of our daily life and most human users will feel comfortable with it. Inevitably, switching between different activities belonging to different pervasive applications can pose a high level of complexity. The switching referred to above implies changing context, interaction technique, interaction technology, etc.

For example, in a smart warehouse scenario, a human worker has to perform different activities such as picking a box up, checking a tool in/out, and moving objects around, all in different locations, times, and contexts. For doing so each worker follows a certain flow of actions to perform the different activities.

The worker will find themselves dealing with a number of pervasive computing applications such as a box handling application explaining the correct way to move a box, a staging area management application running in the staging area and finally a health and safety applications running in the warehouse. Each of the three mentioned applications is accessed through a dedicated interface and interaction device. This will lead to enormous confusion and consistency problems to the worker because of the absence of a reliable interaction model.

Flow-driven interactions as envisioned make user interactions more conceivable by allowing people to interact with multiple physical smart artifacts simultaneously in the real world. Reshaping interactions around the concept of flows in pervasive adaptive applications, defined by a flow-based interaction model, could be of great help to overcoming the limitation and problems of human users' involvement in tasks requiring interaction with pervasive technology. This research is also motivated by the limited number of sufficient studies considering interaction models across pervasive applications. Moreover, challenges such as adaptability and consistency aspects of both pervasive applications and flow-driven interactions form a very strong field for study and investigation. Finally, adopting flow-driven interactions will impose a new set of requirements to build pervasive computing applications.

3. Approach and Methodology

The Top-Down methodology will be followed to carry out and investigate flow-driven interactions against conventional interaction techniques in a pervasive computing setup. A prototype will be built initially to test and investigate the technological aspects of this study and to verify the researched concepts and ideas with real users in closed world assumptions.

The prototype will cover a number of scenarios, each of which will tackle existing interaction techniques with the required user interface design. Moreover, it will aid in designing and testing new interaction techniques for the envisioned interaction model and its new requirements.

4. Related Work

Studies carried out in Ubiquitous computing have resulted in new technologies emerging in everyday situations. As pointed out in earlier sections, the widely accepted concept of workflow (WF) [WfM99] is adopted to investigate human interactions with pervasive applications in performing human activities. The Workflow Management Coalition (WMC) defines workflow as "the automation of a business process, in whole or part, during which documents, information or tasks are passed from one participant to another for action, according to a set of procedural rules" [WfM99]. The workflow's strength is gained from its ability to represent and control those processes in a computerized manner.

Workflow functions as predicted by [SAA99] are used and adopted by different technologies and applied in many areas such as business and scientific workflows. Significant interest in this concept by the scientific and industrial community has evolved and has been boosted by the availability of its enabling technologies [MS05]. Despite its recent interest in human aspects, conventional workflow systems generally lack the integration of the human user's involvement, such as human activities, being part of the flow and differentiable from fully-automated activity.

Workflow language extensions such as BPEL4PEOPLE [KKL+05], are aimed at supporting human activities. Most workflow languages, on the other hand, such as BPEL, describe and orchestrate automated business processes, with partial or complete absence of the human aspects. Hence, the expressiveness of user interactions within such languages is quite limited and questionable [JFGK03]. A true integration of human users in the workflow results in far better workflow models which consider humans as an active part of the model. Moreover, both technological and social acceptance barriers have to be overcome [Kap95]. Yet, the adoption of workflows is hindered by a number of factors; firstly, users' interactions are currently limited to not much more than a key data entry or decision points; secondly, human activities, if considered, are circled with pre-defined rigid sequences of interactions that cannot be changed or altered easily; thirdly, applying design patterns for fully-automated processes on human activities, rather than clear recognition of the distinctive style.

The user interface modeling and generation field has been a fertile one for research. Significant milestones, namely UI modeling languages and technologies, have been achieved forming a base for my research topic. Currently, different features provided by the XML-based user interface description language (UIDL) are available for user interface design such as User Interface Markup Language (UIML) [SV03], Abstract User Interface Markup Language (AUIML) [SV03], and USer Interface eXtensible Markup Language (UsiXML) [Usi09]. Nevertheless, none of these languages have been adequately tested to measure their compatibility with the concept of flow-based human interactions in workflow and pervasive computing systems. Moreover, interaction patterns in workflows form another related topic for investigation. In [GVCW08], a limited study has been reported on managerial and administrative aspects of human interaction patterns with workflow management systems. There is yet no study to report generic human interaction patterns in workflow systems.

Currently, a futuristic view about workflow and its applications is manifested in Adaptive Pervasive Workflows (APWFs). APWF are flows situated in the physical space as an enabling concept for adaptive pervasive applications [HRKD08]. APWFs invoke a number of challenging aspects mainly regarding flow adaptability issues and distribution problems of pervasive flow engines. The integration of the human user as a central player in this concept triggers interaction and interface design, modelling, usability, involvement and many more questions. To our knowledge, the literature written on this field is missing dedicated research defining the nature of flow-based interaction models and their patterns, qualities, efficiencies and effectiveness in executing job tasks and activities, in the context of the dynamic nature of the real world, the human actor and the rich availability of real world context.

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