Demo Abstract: Spatial sensing to support interaction across devices

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I. Introduction

We have built a sensor network called Relate which provides fine-grained relative position information to co-located sensor nodes on the basis of peer-to-peer sensing. The sensor nodes can be attached to mobile devices via the USB port. The devices receive data from the nodes to compute a spatial model of the relative positions of the co-located nodes [1]. This spatial information has been integrated in a set of widgets we call the Relate toolkit, enabling the use of spatial information for different applications [2]. In this paper, we focus on the interaction between co-located devices in terms of how the spatial information can be used to support this interaction and make interaction across devices transparent. We start by explaining the architecture of the toolkit followed by demonstration scenarios to illustrate the capabilities of our implementation.

II. Architecture

The platform is implemented in Java to enable the use of the toolkit on mobile devices, regardless of the operating system. The Relate toolkit consists of six components (see Fig. 1):

1) The Relate Dongles forward raw measurements and host information of co-located nodes via USB to the Relate toolkit, see Fig. 1, (a) and (b) respectively.
2) The Measurement Component decodes the raw measurements and allows a user configureable set of filters to be applied in order to encapsulate the processed data as events for the Location Manager (c).
3) The Host Information Manager processes information shared over the wireless RF network (b). Currently we exchange Relate id (a unique identifier for each node), user name, host device type (such as laptop or PDA) and IP address.
4) The Location Manager aggregates filtered distance and angle measurements and computes a best fit spatial model using non linear regression.
5) The P2P Device Discovery runs a device discovery lookup service, allowing the Relate toolkit to use multicast queries to discover all co-located Relate devices or to discover the IP address assigned to a specific Relate id (f).
6) The Spatial Model contains knowledge aggregated from three sources, (e,) (d) and (g) respectively and encapsulating it in a service providing relative coordinates, the Relate id, user details and the IP address. This abstract representation of a co-located mobile device is passed to registered applications, (h).

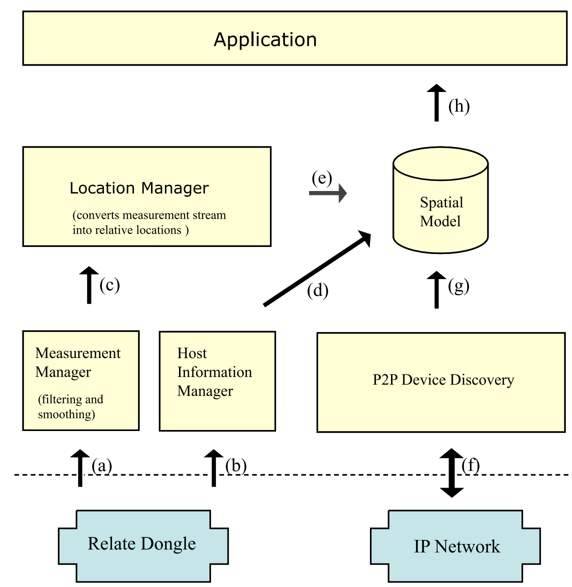

Fig. 1. Relate Toolkit Architecture

III. Demonstrator

We use three mobile devices, a Powerbook, an iBook and a PDA, in the demonstration scenario (see Fig. 2). The demonstrator shows six following aspects of the Relate toolkit:

A. Device Discovery

For the device discovery we run the application on two laptops and a PDA. The Relate sensor nodes detect other nodes in proximity. This triggers the nodes to start acquiring distance and angular measurements and forward them to the Relate toolkit. The toolkit builds a spatial model which can be viewed graphically by the *device map* Relate widget. This widget shows an abstract representation of the co-located devices in the relative spatial arrangement. This widget is illustrated in Fig. 2, where the Powerbook device (a) shows the device

Fig. 2. Relate Toolkit Prototype

arrangement from its point of view, which is different from the device map of the iBook (b).

B. Device Position Update

The Relate sensor nodes constantly acquire measurements which are aggregated into the local spatial model. Any movement of the devices can be observed in the device map widget as a movement of the abstract device icon. Movement appears different on each device display, as the graphical abstraction icon moves relative to the local device position and orientation. The device map widget is updated at 200ms intervals to reflect the changes in the Relate model. Although the spatial model is updated with each measurement, this display update rate gives the appearance of smoothing jitter in the calculated device positions for the graphical display.

C. Filter Inspection Tool

An additional method of smoothing location data is to apply a set of filters in the Measurement Manager. To support debug activity and error detection we implement a filter inspection tool. This allows the user to see a dynamically updated graphical representation of distance and angular measurements between two nodes, while configuring filters. Here, any modifications in the filter configurations are immediately visible in the same window as a *before* and *after* display.

D. Device Removal

When mobile devices move out of sensing range, or the user stops the Relate application, the remaining active Relate nodes stop receiving measurement updates. If the spatial model receives no update information for a pre-defined time, it is assumed the node has disappeared and it is removed from the system. On the graphical interface, the device icon simply disappears.

E. Host Information Exchange

The Relate nodes exchange host details such as Relate id, IP Address, device type and user name over the Relate node RF network. This information is visible by a right click menu over the graphical representation of the mobile device. The RF network is limited in terms of the amount of non-measurement information that can be exchanged, however, we assume further information can be exchanged by wireless IP network when necessary (see (f) in Fig. 1). For example, we have implemented a scenario where the user can right click on the graphical representation of another mobile device and receive a virtual business card of its user in the VCard format by knowing only the devices relative location. Here, the amount of contact information is too large to be transmitted only over the RF network, so the Relate toolkit implements transparent use of the IP network.

F. File exchange

The Relate toolkit's implementation of transparent IP network access allows users to send files to remote mobile devices by dragging and dropping the file on their abstract graphical representation. Without the Relate Toolkit, the user would need to know the IP address or machine name of the remote device in order to connect and transfer the files over the network.

IV. Conclusion

The Relate toolkit demonstrator illustrates how spatial sensing can be used to support transparent interaction across mobile devices. We provide several concrete application scenarios and show how the use of spatial information can benefit the user through the use of Relate toolkit widgets. Further research is planned to explore new ways to use spatial information and new Relate toolkit widget designs to support multi-device user interaction.

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References

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