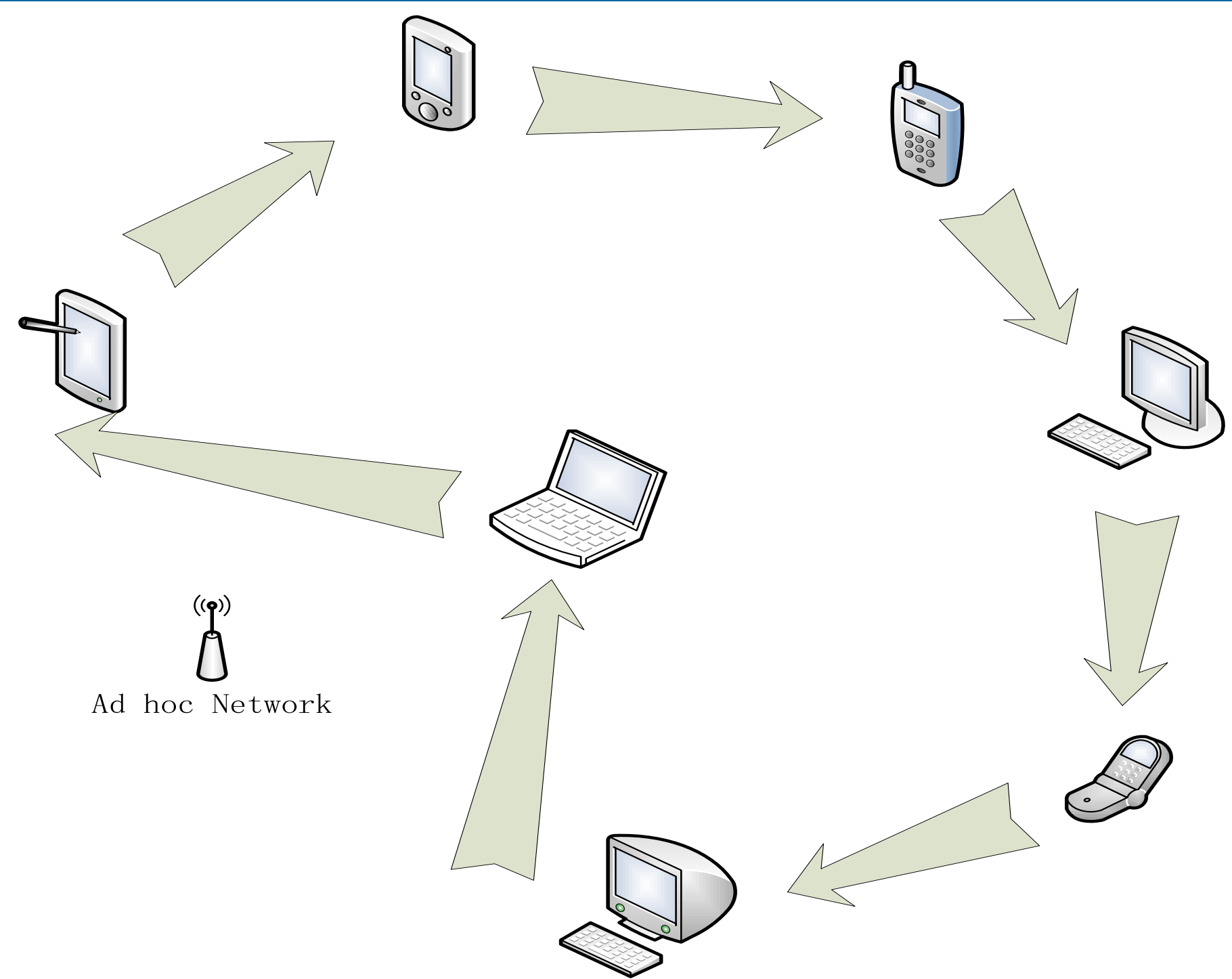


Agent Based Application Programming Framework for Ad-Hoc Networks

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Application Programming of Ad-Hoc Networks



Wireless ad-hoc networks have many important advantages over centralized networks:

- a. They can be organized as peer to peer networks.
- b. They do not rely on the existing infrastructure and can self-organize.
- c. They can be created in almost any kind of communication environment.
- d. They support communications with any devices with wireless interface.

So wireless ad-hoc networks have many application fields:

- a. Search and rescue in disaster situations
- b. Civilian outdoor applications, e.g. taxis, cars, sport stadiums
- c. Multimedia services between different mobile devices, such as cell phones, PSPs

Current State of Application Programming for Ad-Hoc Networks

The ad-hoc nature brings two main challenges: *mobility management* and *coordination* among mobile nodes.

Current application programming for ad-hoc networks can be considered in two categories: *middleware* and *language*.

Middleware approach: Tightly coupled with applications and there is no single general middleware that can resolves all application problems.

Language approach: Usually are extensions of existing language and libraries that provide new language constructs. Do not provide implemented application services, developing efficiency is lower than middleware approaches

Developing applications for ad-hoc networks has three main goals:

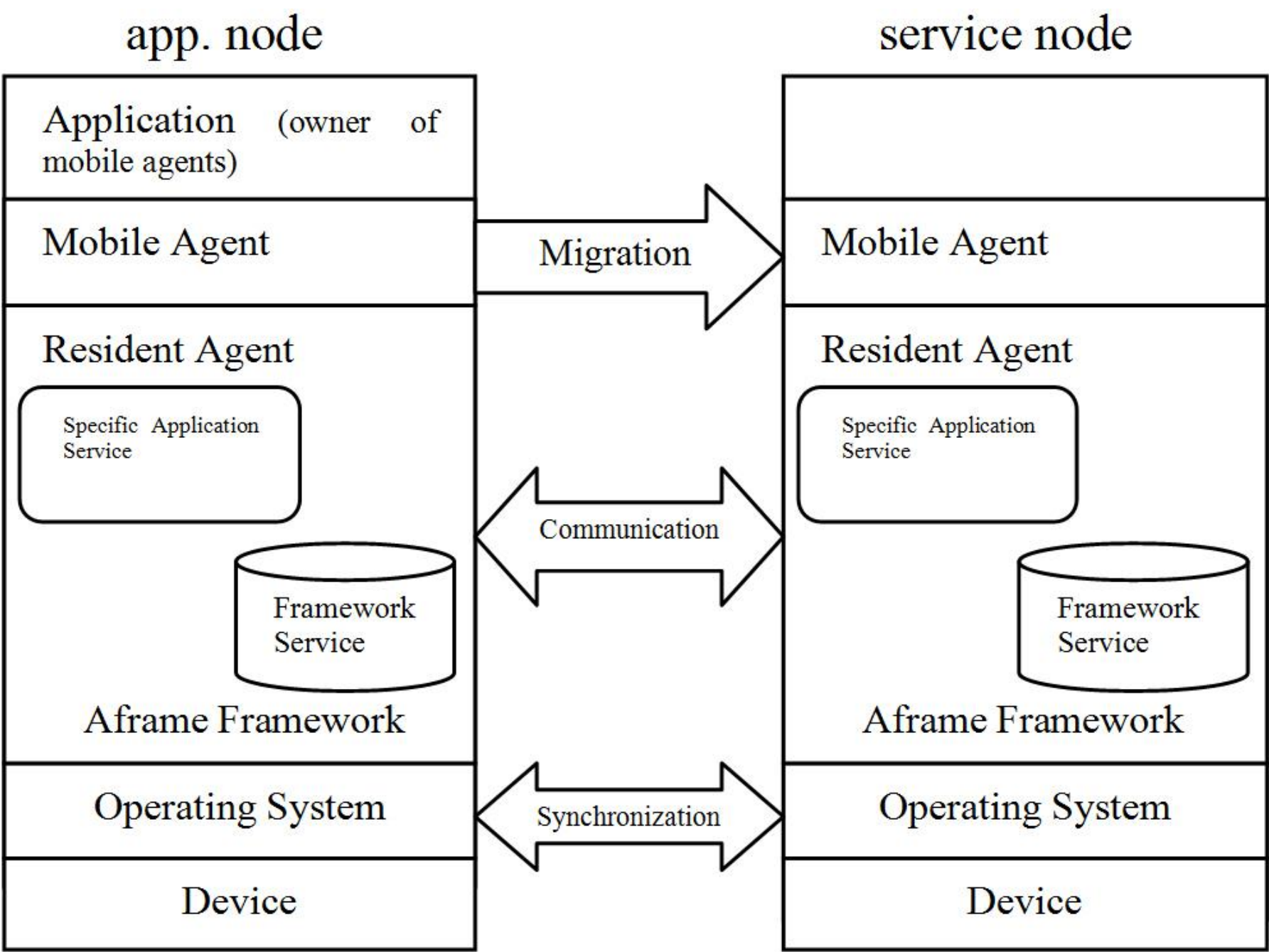
- a. Supporting high-level application programming
- b. Providing a systematic approach
- c. Supporting easy and effective programming

Objects of Aframe

Integrating advantages of middleware approach, language approach and software agent technique, developing a multi-layers framework to support application programming for ad-hoc networks with the following functions:

- a. Programmers can easily and effectively develop applications
- b. Programmers can easily extend application services
- c. Mobile agents can self-adapt to dynamic network topology
- d. Mobile agents have flexible migration strategies
- e. Agents can cooperate with each other

Overview of Aframe Framework

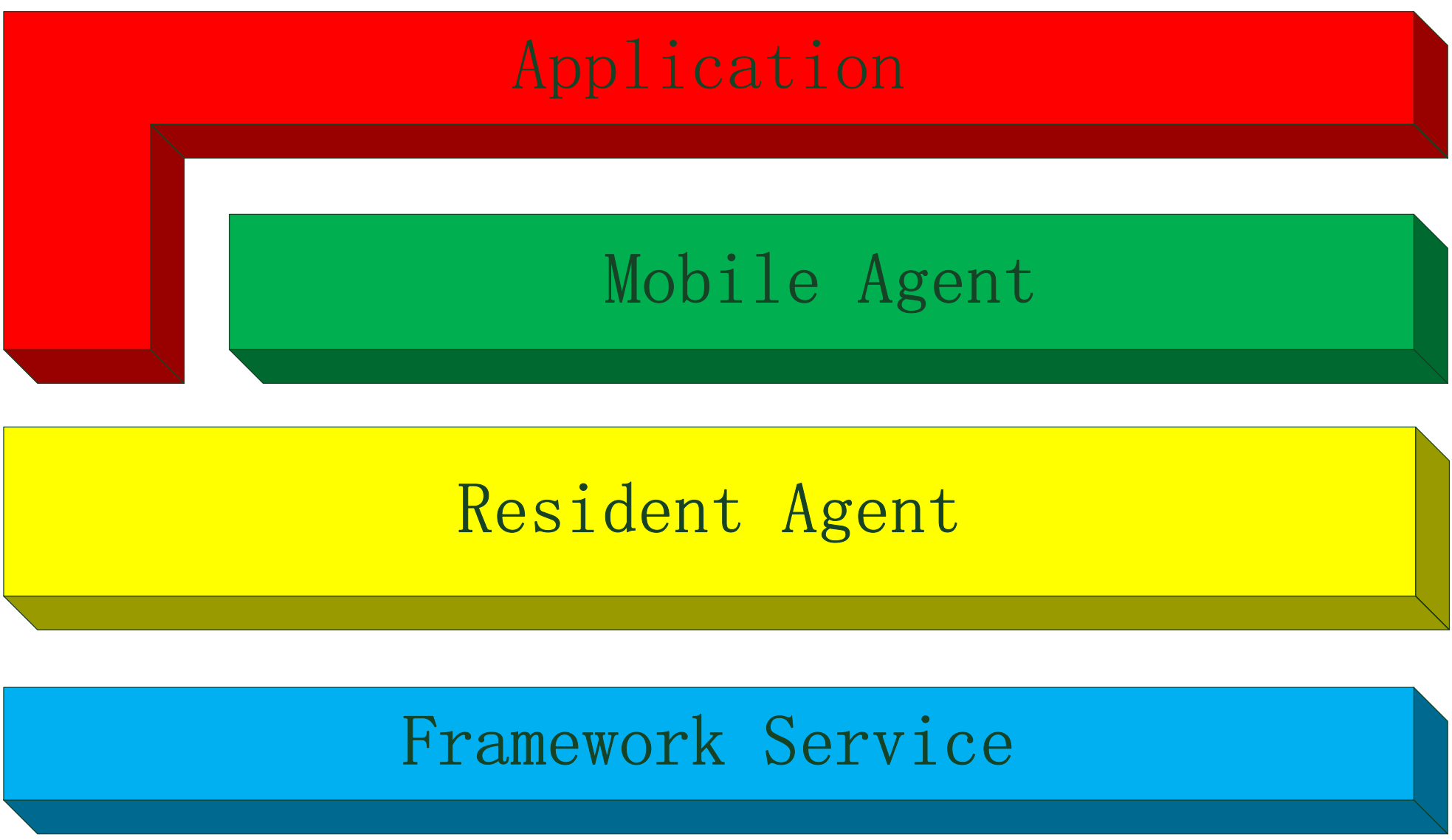


The programming and system model of Aframe is shown in left. In Aframe, an application programmer programs resident agents to provide all the application services on nodes of an ad-hoc network. Such application services provide local resources for the application to visiting mobile agent. To program resident agents, the programmer can invoke, configure and extend generic application services provided by Aframe.

A mobile agent can automatically migrate around ad-hoc network with its state and executing results. It can dynamically use different application services provided by resident agents on local nodes for accomplishing the mobile agent's specific application tasks.

Mobile agents are created by applications. An application as the owner of a mobile agent can send the mobile agent to travel in an underlying ad-hoc network and receive the mobile agent's back to the application's node. It does not need to be deployed on every node in ad-hoc networks.

Architecture of Aframe



A. Framework service layer

It is at the bottom of the framework. It provides the core functions and services to the upper layer. Framework services help agents self-adapt to ad-hoc networks, such as adopting dynamic network topology, as well as providing general applications supports. The framework services are only be accessed by the resident agent layer but not by other layers. The resident agent layer can invoke any services from this layer, and then provide them to mobile agents.

B. Resident agent layer

Resident agents provide all the local application services to visiting mobile agents. A resident agent can be automatically deployed to a new mobile node when it is joining the underlying ad-hoc network. Once a resident agent is deployed onto a mobile node, it will stay there to provide application services. Framework services only provide basic and generic functions and services for applications. Application programmers can also develop new application services and deploy them to this layer.

C. Mobile agent layer

Mobile agent is mainly used to execute different application services provided by resident agents. It does not contain application services in its code. It just contains some basic data, such as its migration strategy, processing strategy of executing result, as well as computation and communication results. Meanwhile, mobile agent is also used to transfer necessary resources or application services to some mobile devices when they do not contain such resources or services.

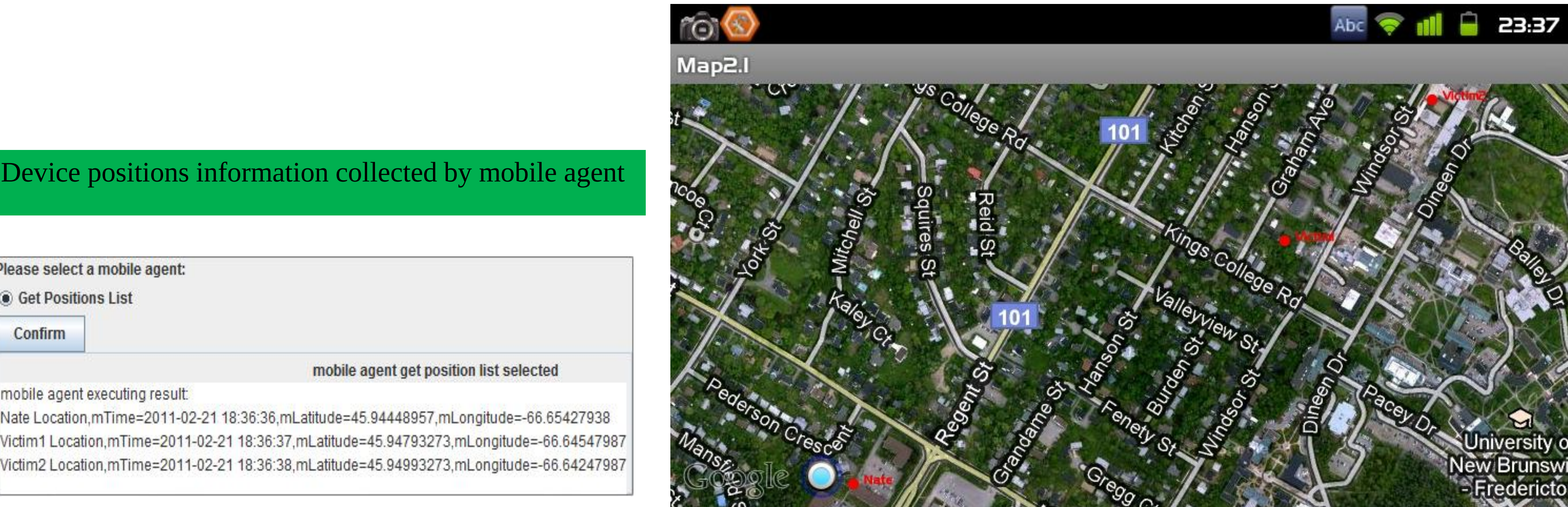
D. Application layer

Applications are owners of mobile agents. An application provides the user interface to its user who uses a mobile device. Using the user interface, the user can select and release a mobile agent to execute a specific application task, or release multiple mobile agents to accomplish different tasks simultaneously. Aframe supports multiple agents with multiple application owners working at the same time.

Application Examples

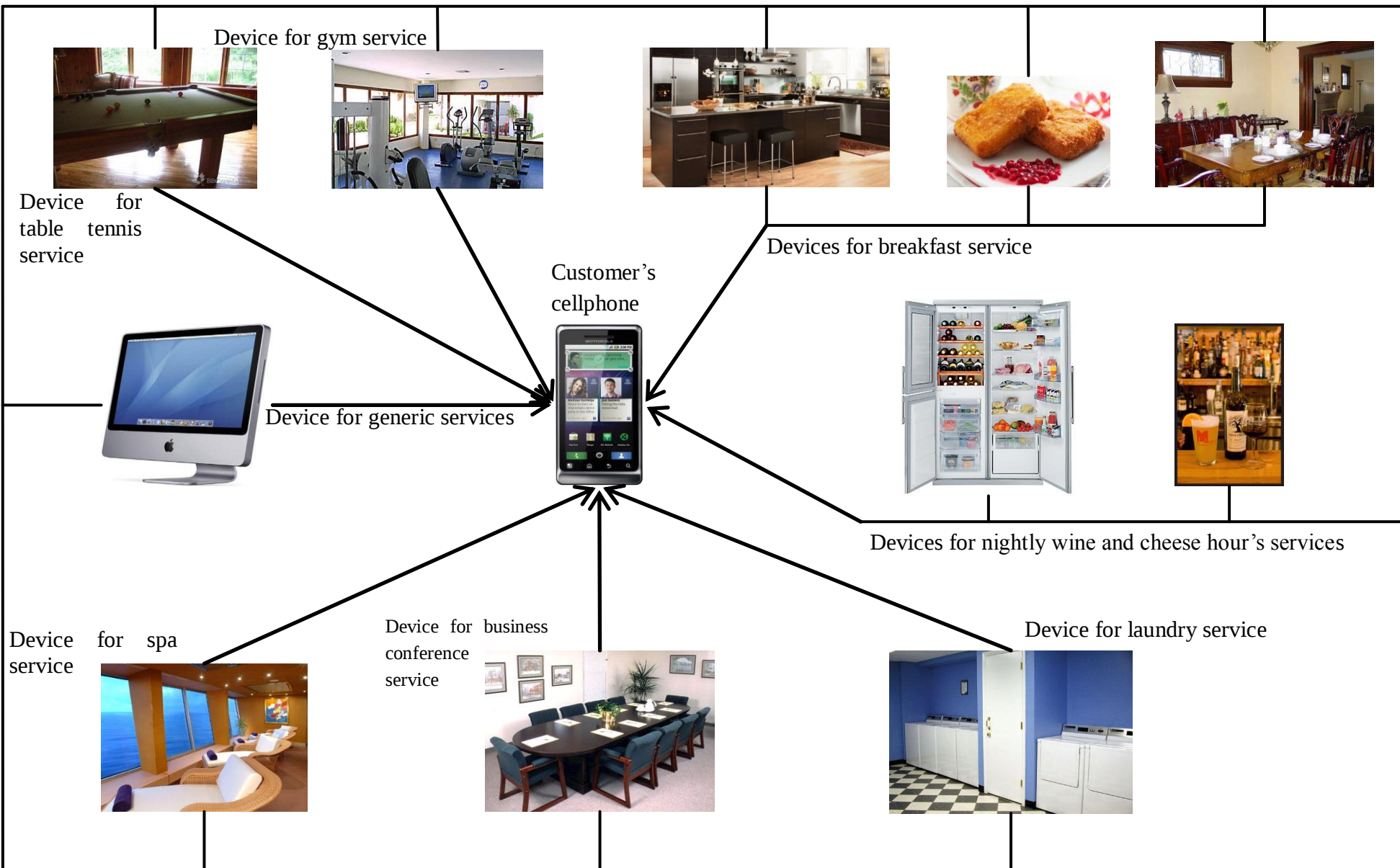
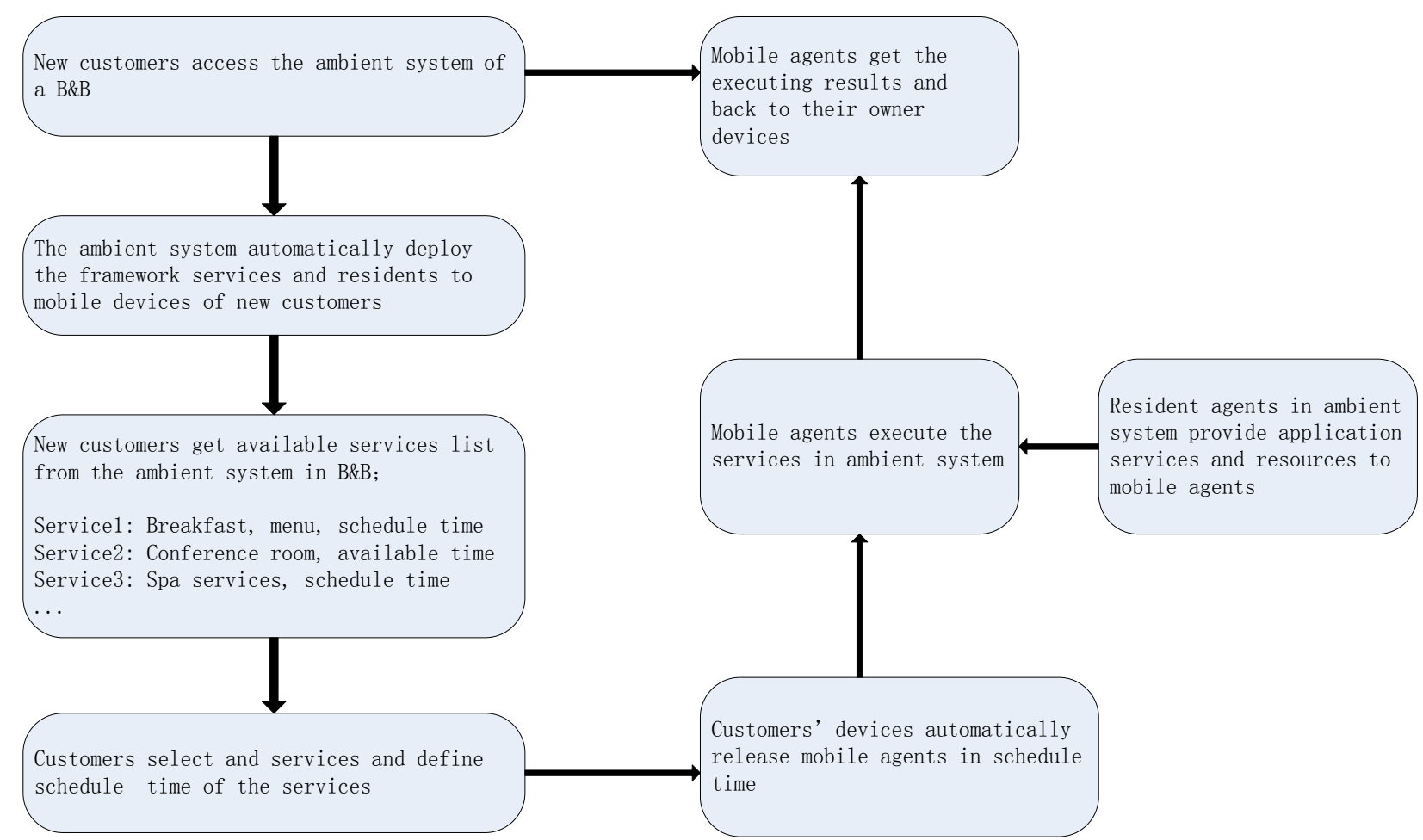
With the development of wireless ad-hoc network technique, more forms of such technology being used in disaster scenarios. Software agents are very suitable in ad-hoc networks, such as the cooperation of agents in ad-hoc networks can improve the efficiency of performing various tasks. Especially in disaster rescue scenarios, time efficiency is very important. Also, we can imagine that in a disaster, the major requirement is a common picture about the positions of the victims and rescue people, as well as some relative information of them. Therefore, we designed and developed a demonstration application about disaster rescue by using Aframe.

In the application, we used one laptop and two Android cell phones for testing, all of which contain GPS components to get their local positions. We assumed that the rescuer named Nate using the laptop released a specific mobile agent to collect positions and relative information from the two victims using Android cell phones. Firstly, we deployed the resident agent to all the three mobile devices. The resident agents can provide necessary application services to mobile agent when it is visiting them. Thus, the mobile agent can automatically migrate around all the three mobile devices, automatically executing there and finishing this task and back to its owner. Finally, from the following figures, we can find that the mobile agent had successfully collected the positions list and relative information (names of the mobile nodes and their local time) to its owner, and shows a common picture about their positions.



Common picture for device positions displayed by application

The working procedure of the ambient system with Aframe



We designed an ambient system with Aframe based the underlying ad-hoc networks for B&B. We deployed the devices to all the places which provide services to customers, such as the kitchen, fridge, conference room etc. After a customer finish the registration in the front desk of the B&B, the service computer will automatically deploy the agents and generic services to the customer's cellphone, such as the current available services list. Also, the service computer will update the services list to customers and other service devices periodically. Then from the user interface of this cellphone, the customer can select the services which he requires. For example, if he wants to book a conference room in a schedule time, he just needs to select the business conference service in the user interface, and then his cellphone will automatically release a mobile agent to the device of conference room. Once the device in the conference room receives this service request from the mobile agent, it will automatically verify the identity (or name) of the customer with the service computer in front desk. If it passes the identification, the device in conference room will check about the schedule time is available or not. Finally, the mobile agent can get the result and automatically bring it back to the customer's cellphone. Meanwhile, if the customer wants to make an appointment of the breakfast, the services devices for menu, kitchen and dining room will collaborate together; the customer can first get the information about the breakfast, such as the current menu, available time or some extra services from the Kitchen, and then define the breakfast and schedule the time for it based on these information. Moreover, as the above figure shows, customers in the B&B can get many other automatic services by using the ambient system with Aframe. The working procedure of the ambient system in B&B is shown in the left figure.