Designing Community Care Systems with AUML

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Abstract.

This paper describes an approach to developing an appropriate agent environment appropriate for use in community care applications. Key to its success is that software designers collaborate with environment builders to provide the levels of cooperation and support required within an integrated agent–oriented community system. Agent-oriented Unified Modelling Language (AUML) is a practical approach to the analysis, design, implementation and management of such an agent-based system, whilst providing the power and expressiveness necessary to support the specification, design and organisation of a health care service. The background of an agent-based community care application to support the elderly is described. Our approach to building agent–oriented software development solutions emphasizes the importance of AUML as a fundamental initial step in producing more general agent–based architectures. This approach aims to present an effective methodology for an agent software development process using a service oriented approach, by addressing the complex agent environments decomposition, abstraction, organization and software development process activities characteristics, whilst reducing its complexity of the agent–based by exploiting AUML's productivity potential.

1 Introduction

The providers of public and private sector health care services have, in recent years, been faced with some radical changes in the society they serve (Peckham et. al., 1996). This paper considers why agent technology may be useful in developing a service-oriented approach to the provision of community care where multiple services have to interact to provide an effective and efficient service. While many of the services are provided by physical agencies through programmes of visits, information technology can do much to reduce social isolation by providing a range of information services (SeniorWatch, 2000) which can be integrated so that they are effective and usable by the client.

Community health care is dynamic, complex and progressive. Its aim is to provide such services as are necessary to maintain a client's quality of life in the community when they are unable to provide for themselves, thus maintaining their independence. Provision is delivered by a wide range of disparate, independent organizations and agencies, each having their own objectives, of which the provision of community care is typically only a part. The objective is to integrate these services with their other responsibilities in a coherent and efficient manner (Beer & Huang, 2002). Agent-based community care services are a new approach that automates the process of linking constituents with

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their core competencies quickly and effectively on the Internet. Important aspects of this development include the need to:

- use agent–oriented architectures, models and methodologies to create flexible roles,
- add and delete services as required,
- more closely model the integration of separate services and,
- dynamically change the relationships among services as conditions change.

Huang et. al. (1995) introduced an agent–based distributed medical care system which allowed patients' own needs to guide their individualized care management. The community care service agents are able to not only support traditional services but also provide a range of utility services such as individual care planning, health service advice, customised information filtering etc., all of which are intended to maintain the client's integration into the community. In the real world, individual care providers currently use their own heterogeneous databases, workflows and command and control systems with little or no integration between them (Beer et. al. 2003). This causes difficulties, not only in the provision of the most effective response to emergencies, but also in the management of routine care as the client's requirements change, often quite rapidly. Current systems do not provide the flexibility to allow such changes to be implemented as rapidly as one would desire. This is because an Individual Care Plan is specified by the Social Services Department of the Local Authority. It then contracts various agencies to actually deliver the various components of the care as appropriate. There is therefore no single agency with the overall authority to plan, manage, deliver and monitor the provision of community care. To this must be added the various health care services, and the emergency services, each of which acts independently and have their own independent records and command and control structures but are essential components in the delivery of the total package (Beer et al. 2001). Similarly, there are the large numbers of informal carers (family, friends, neighbours etc.) who are currently almost totally ignored by the system, but who also provide invaluable support.

In this paper we describe the principles behind a distributed Agent-Based Integrated Community Care (INCA) system. A demonstrator system, implemented using the ZEUS agent-building toolkit (Nwana et al., 1999) is also described in order to demonstrate the feasibility of the approach and its potential practical benefits. This demonstrator shows that the technologies proposed allow effective communication without compromising integrity and privacy. In particular they allow an approach to be taken that allows minimum collection of information in that the Home service agent can be configured so that it only releases private or sensitive data in case of an emergency, when such information is of value.

The objective of the INCA Project is to investigate how community care can be developed in the internet age through the use of multi-agent technology. The motivation for this has been a consideration of the agent society's social abilities in:

- Promoting effective care systems that:
    - provide better services and resources to clients,
    - enhance social interaction between them, and with their carers
    - deliver more effective care
- Providing the high-abstraction level care management strategies by linking all relevant agencies into a single framework of accountability.
- Giving an in-depth understanding of the health information framework that underpins the delivery of high quality, effective community care, including the formularization of the links between the disparate agencies involved.
- Establishing a single Agent-Based care monitoring facility that can be used by all care

professionals to assist in effective monitoring and diagnosis.

- Developing cooperative structures within the community structures to change service provision and care policies through the use of automated agent involvement in planning, scheduling, organizing (both formal and informal) care and even directing care service programs.
- Devolving care management and responsibility to those providing the care by providing shared supervision and teamwork and by separating the organizational from the social requirements, developing a much more responsive and client centred environment that adapts rapidly to changing needs.

Some of these objectives have already been investigated in the medical domain through the use of multi-agent system architectures. For example, the GUARDIAN system (Hays-Roth & Larsson, 1996) considered patient monitoring in a Surgical Intensive Care Unit. Support is provided for collaboration among specialists, each an expert in a specific domain but fully committed to sharing information and knowledge among each other and the nurses that continuously monitor the patient in the physicians' care. A system devoted to diabetes care has been presented, where cooperation not only between the medical specialists, but also others, such as administrators is supported within the agent community (Lanzola et al., 1995).

A more general Agent-Based telemedicine framework has been reported (Dela Mea, 2001) that can assist specialists in diagnosing difficult cases through information sharing, cooperation and negotiation. In this case each specialist has their own Tele-medicine-Oriented Medical ASsistant (TOMAS) agent that behaves as a medical assistant and has two generic functions:

- an agenda for managing appointments, and
- methods for access to patient records.

Support for tele-medicine is provided through the remote exchange of patient data, cooperative annotation of cases and negotiation of appointments. These approaches have been greatly assisted by moves to standardize medical information through the formalization of patient and other records (Department of Health, 2001). Some of the flexibility offered by the mobile access to records and services is being demonstrated by the Ward-in-Hand project (Ancona, 2001), but only in the relatively restricted environment of a conventional hospital ward.

The INCA project aims to take these forward from the purely medical domain and integrate them into the general community care environment, where the linkages are less formal and effective cooperation and negotiation is essential if appropriate care is to be delivered. A major difference is that it is rarely possible to share information as freely as within the purely medical domain because of the involvement of different agencies and individuals with widely differing requirements. The agent community therefore has to act as a coordinator and filter to ensure that appropriate and correct information is distributed to all concerned. Also, since help is likely to have to travel some distance it is often better to provide whatever assistance is readily available in a timely manner, rather than the optimal solution that may arrive too late.

2 The INCA Demonstrator

The demonstrator uses multi-agent technologies to enhance the mechanisms for the systematic and widespread assessment of the health of the elderly out-side of a conventional clinical care regime. Enhanced assessment provides a valuable and timely source of information and knowledge that enables the optimization of care provision and management. Non-invasive assessment technology provides a source of health information that is well suited to identifying subtle, yet important,

changes in an individual's condition. This can then be combined with appropriate knowledge sources available elsewhere on the agent network to trigger pre-emptive care and treatment (Haigh & Yanco, 2002). Appropriate care is then be provided in an effective and timely manner.

It aims to improve:

- Current community care systems by using agent-oriented engineering solutions to design a new cooperative, coordinated, collaborative health care e-service by the adoption of agent-oriented models, platforms and methodologies.
- Coordination between social services and medical care services, organizing and managing these concurrent actions in an effective and inter-operative way.
- The provision of positive assistance to maintain and enhance the quality of service and the provision of routine care as specified by the Individual Care Plan.
- The integration of services by adopting a service oriented approach

INCA provides a complex community care service by using Agent technology solutions to organize and allot limited resources and services to a large number of care requirements. From the released work, it became clear that to maximise the effectiveness of agent–oriented community services activities, it would be prudent to have clear methods and models for analyzing, designing, organizing, controlling and managing agents' cooperation, communication and interaction.

3 Agent-oriented UML and its Concepts

AUML (Parunak & Odell, 2001) (Bauer et al., 2001) provides a new way of thinking about agents and how they interact with each other and their environment. Unified Modelling Language (UML) is a de facto industry standard established by (Booch, 1999) that:

- presents a form of notation for object-oriented analysis and design;
- provides system architects working on objects analysis and design with one consistent language for specifying, visualizing, constructing and documenting the artefacts of software systems, as well as for business modelling (OMG, 1999).

UML provides a designable meta-model that represents a collection of semantic models including static models, dynamic models, usage models, and architectural models. All the models can be constructed, viewed, developed and even evaluated during the time of systems analysis and design. provides A semantics package is provided, which allow UML model elements and notations to work independently within different packages for different processing, as shown in Figure 1.

This aspect of the software development approach (e.g. representational formalism) leads us focus on using UML notations to represent Agent concepts (e.g AUML), when redesigning and reorganizing the existing Community Care & Alarm Services systems.

The use of Agent-oriented UML provides a formal platform for analyzing, designing, organizing, managing agent behaviours and modelling an agent-based system. In order to fully exploit the flexible behaviours and productivity potential of agents, AUML was selected to assist INCA process for agent system design and development.

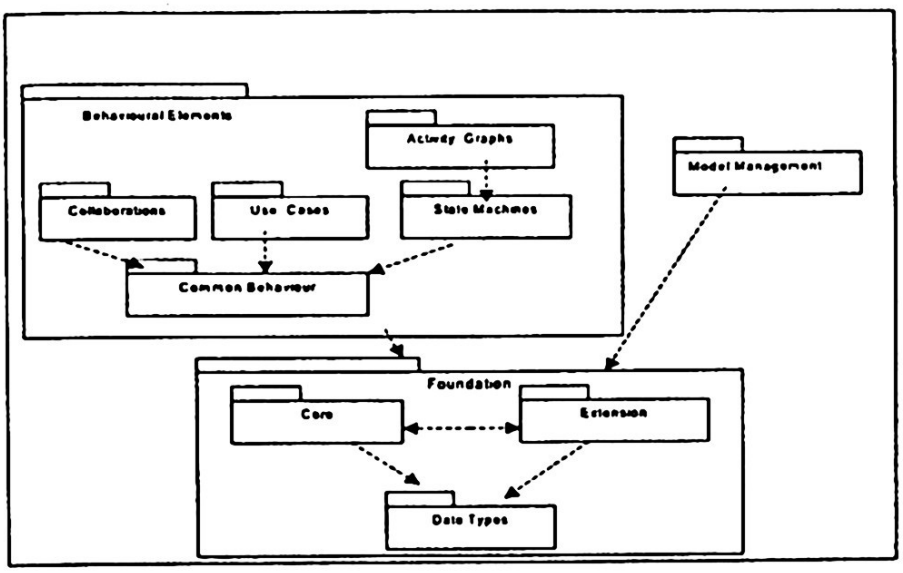

Figure 1. UML: Package Structure (OMG, 1999)

4 INCA System Design and Development with AUML

After considering agent concepts at an abstract level, the next step was to develop a practical design and implementation for INCA systems through the use of agent-oriented Unified Modelling Language (AUML)

First, it was necessary was to analyse all the needs of an agent–oriented community care environment and analyse the requirements with the agent models. This stage would identify the agent-based roles from all of the available care service resources (including description and identification of the agent tasks, health services and components). In practice, community care agents in INCA system could be as described in Table 1, based on the UML Use Case models (Beer et al, 2003).

During the INCA System development, agent-based UML semantics and notations were used to address the overall architectural complexity across agent domains by using a set of UML graphical diagrams, such as use-case diagrams, class diagrams, agent behaviour diagrams and implementation diagrams. The sample diagram (Figure 2) is a notation diagram of Agent-based health care Service Supplyi, which shows how a series of co-operational agents gathering domain operational information achieve their tasks and domain goals. The model begins with roles/agent initiation and definition, and moves to the roles 'planning for supplying emergency service' and organizing agent behaviours, relations and responsibilities, followed by loading some particular class requirements. Finally, this model provides a small autonomous agent domain to generate operations such as an executable service package to users.

NAME	DESCRIPTION
Care Co-ordinator	The agency responsible for providing the range of services necessary to ensure that the Client is properly cared for. The Care co-ordinator is responsible for preparing a Care plan and for monitoring its effectiveness in meeting the needs of the Client. This is often the Local Authority or some other official body with a legal duty to provide the necessary care.
Care Provider	The various agencies and individuals responsible for providing the care specified by the Individual Care Plan. This will include Social Workers, Health Care Professionals, Care Assistants, Emergency Services, and Social Services etc. who can provide an extremely wide range of care services, if required.
Informal Carer	The various relatives, friends, neighbours etc. who provide some form of support and assistance in an informal way (i.e. outside the Individual Care Plan), but it is often essential to allow the Client to remain resident at home. This is often flexible and responsive and can range from totally unstructured and so not recognised at all in the Individual Care Plan through to fully recognised and integrated with the efforts of the professional carers.
Client	The person who lives in their own dwelling (either an ordinary house or a sheltered home) and who receives a package of community care services. This package may range from very minimal interventions, such as social alarm systems, through to an intensive mix of community support services.
Emergency Services	This agent provides appropriate assistances and services during the emergency events. This is often flexible and responsive and through to fully recognised and integrated with the efforts of the professional emergency supports such as Ambulance, Hospital, Fire Service Department etc.

Table 1: The sample of community care agents in INCA system (Beer et. al., 2000)

AUML is much more than a program language and modelling design diagram. It is concerned with agent domain architecture modelling and it provides a range of declarative models. Functionally, UML is a key ingredient in generating agent architecture and approaches to the agent system devolvement processes in detail and it is able to provide the instruction and design platforms by defining all variant and invariant roles of the agents describing their attributes and dynamically organizing pre and post conditions for operations.

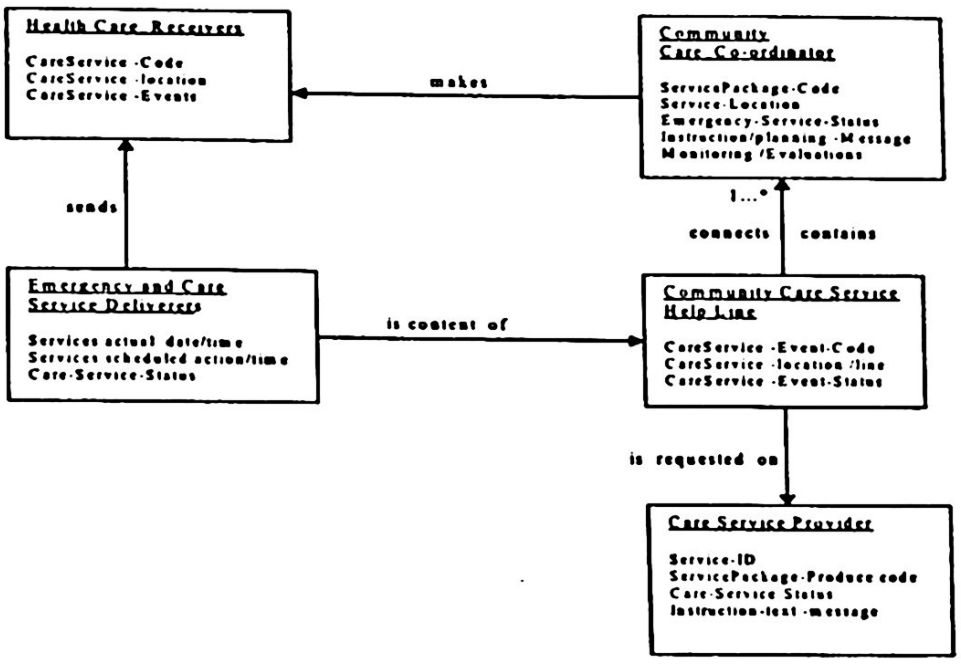

Figure 2: AUML real-time notation diagram of Community Care Services Supply

Agent-oriented UML is a modelling platform that describes the formal specification of the function, structure and behaviour of agents and multi-agent system. It has three main categories for describing system artefacts and information; static, dynamic and descriptive (OMG, 1999). Each category solves a type of domain problem. The classification is given in Table 2.

Category	Artifacts
Static	class, package, components and diagrams
Dynamic	Use-cases, interaction (sequence, collaboration, state chats, activities diagrams
Descriptive	Class descriptions

Table 2. UML artefact categories (OMG, 1999)

An agent-oriented UML model represents the static category by describing agent requirements in detail such as classes, packages, diagrams and components. The dynamic artefacts describe the communication among the components inside a shared common agent system. Descriptive artefacts are used with the other diagrams to support the description of information represented in different perspectives. The diagram below is an AUML-Use Case diagram of Community Care Service Scheduling [Figure3], which is a modelling diagram representing the technical roles and routing of community service supply. It allows knowledge-level agents to be linked efficiently and to share and exchange resources in a common communicated agent architecture and to achieve the "Rational Effect" domain goal.

The next stage is modelling, which involves gathering a range of state of the art techniques and

models for communication, interaction, coordination and control. It can be divided as the *interaction model* and *acquaintance model* (communication, conversation policy, appropriated protocols and negotiation rules among agents). This model represents the technical roles that allow knowledge-level agents to be linked efficiently and to share and exchange resources in common agent architecture. Such interactive community care supply routing can be seen in Figure 4. This is an example of providing care services routing, which illustrates that both official and unofficial care producers/agents (such as *Care Provider, Inform Care, Care Co-ordinator*) could provide an individual care plan and community care services for Clients through the negotiation agents.

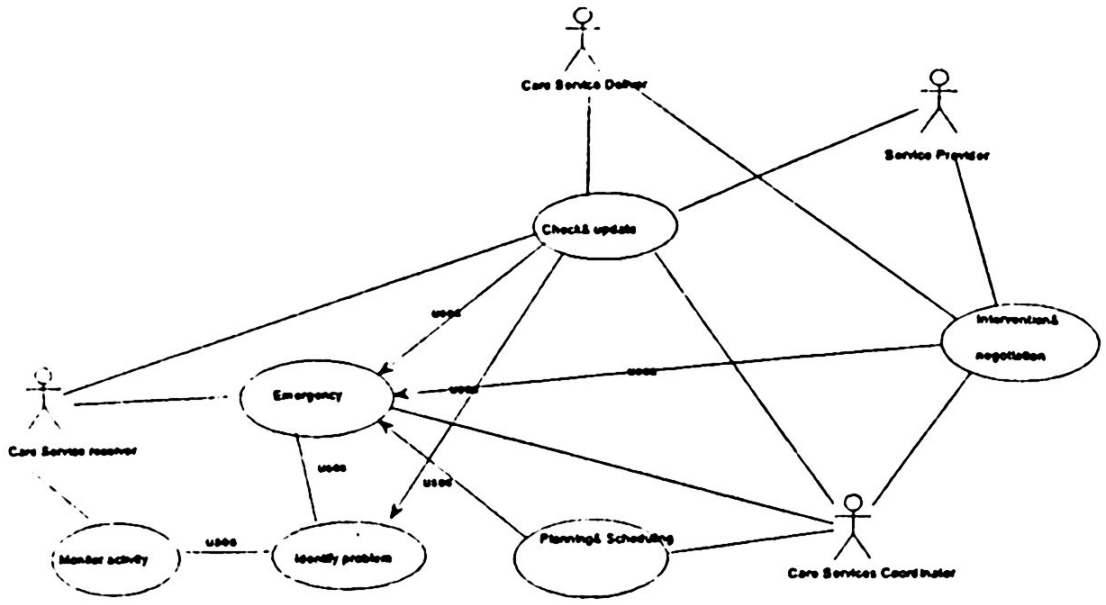

Figure 3: AUML: Use Case diagram of Care Services Scheduling in INCA system

Once the individual care plan has been established, care services required to assist the Client must be managed and controlled by the agent system. Such interaction demands communication messages to be passed and routed as shown in Figure 5.

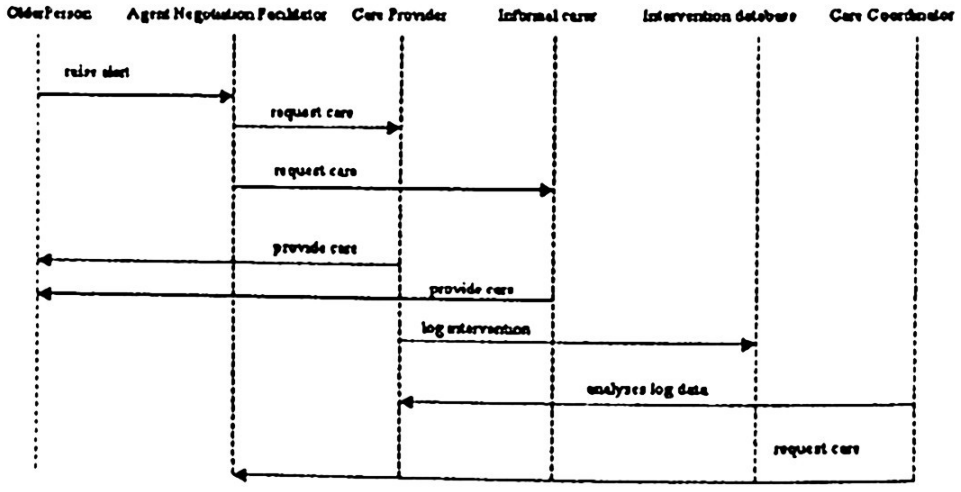

Figure 4: AUML: interaction diagram of an individual care plan and communication routing for older person

Furthermore, the main contribution of AUML to INCA work is the attempt at making the design and development of a multi-agent system as simple as possible. It greatly simplifies the configuration and organisation of agents, the endowment of communication capability and the cooperation capability of agents. This is achieved by mimicking real-world solutions to the current care service activities [Figure 6].

5 Conclusions

The development of Agent-oriented community care systems unveil many unexpected challenges and opportunities to create more advanced distributed e-service systems by fully using agent capabilities and responsibilities using a service oriented approach. This allows us to develop new service styles which lead to reduced costs, improved communications and affect the way we live, work and do business. For example, this paper considers the issues associated with community care of the elderly and infirm. This is only one of a range of care services and we are now using the same methodology to consider the issues associated with child protection. In some cases the same services can be used, while in others new ones need to be developed to meet the different needs. Considerable savings could result from sharing services when appropriate.

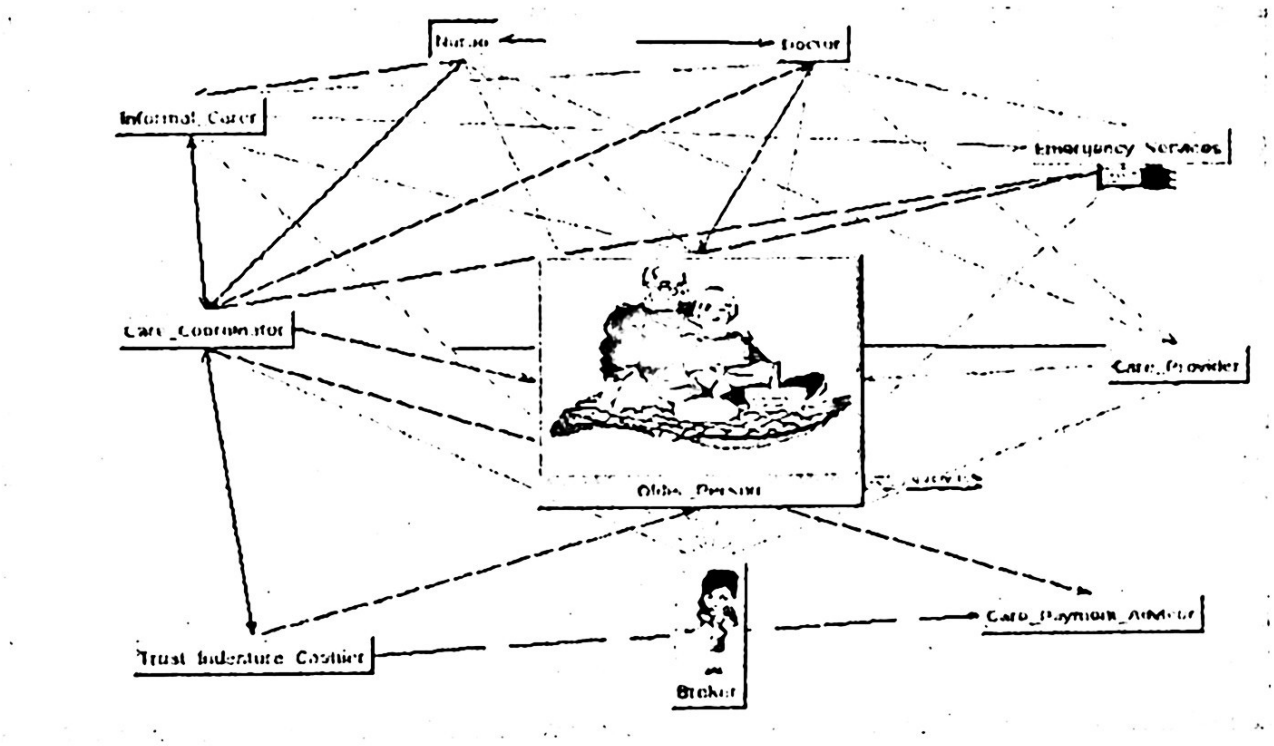

Figure 5: Community care service message passing and interactive routing

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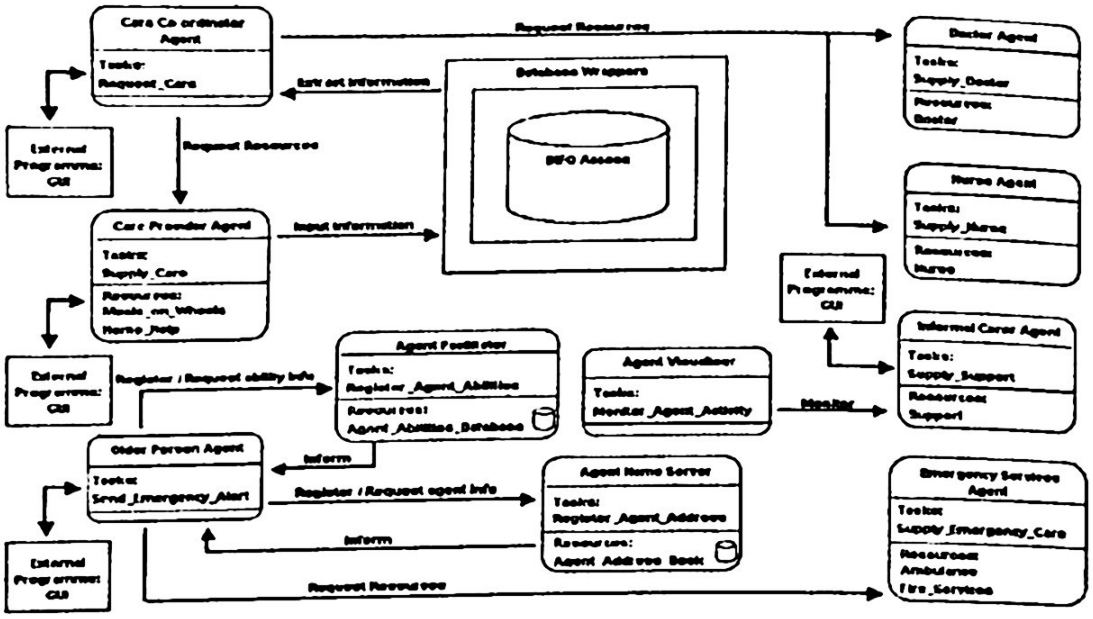

Figure 6: The Overall Architecture of the INCA Prototype

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