Cloud Computing with Intelligent Agents to Support Service Oriented System Control and Management

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Cloud Computing with Intelligent Agents to Support Service Oriented System Control and Management

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***Abstract*- Over the past few years, Cloud computing has becoming one of the revolutionary technologies in ICT which grows in both popularity and importance, both in industry and in academic domain. More and more private companies, government organizations and institutions are convinced and happy to promote Cloud to improve both connectivity and instant social ability. For IT services and solutions for business, Cloud-based platform promises to offer better business intelligence and productive experience by using unified communications, consistent collaborated data and service management. It is well believed that Cloud Computing will also bring a revolution in the healthcare IT sector along with other ICT business. To exploit Cloud computing productivity potential, this paper focuses on adopting Cloud computing technologies with agent-based solutions to support service oriented system control and management. The on-going research and practice demonstrates an application to the management of community care provision, which shows transforming to Software-as-a-Service (Saas) with the combination of a private healthcare cloud and integrated agents can improve business efficiency by providing flexible services scheduling, smarter health care services control and management.**

Keywords- Cloud Computing Theories; Service-Oriented Systems; Intelligent Collaborative Agents Based Solutions; Agent System Architecture; Cloud Based Service Engineering and Provisioning

I. INTRODUCTION

A. Transforming Service Oriented System Operations into the Cloud

Service-oriented solution is one of the most significant revolutions in software engineering. Services are realized by encapsulated software components/units. Their interfaces are self-describing in order to publish, discover and dynamically bind services [14]. The service-oriented architectures are widely used to implement distributed systems within an integrated communication and interactive environment. Service–oriented system software development aims to develop a process that defines the way real world components and real life services should be represented, interpreted and transformed into a Cloud-based environment [1].

Service-oriented applications create operations which can interact with others by providing and consuming services (Figure 1). It perfectly matches with the new development of Cloud computing with solutions for Service-oriented System's development, control and management. Compared to the traditional system, Cloud computing offers mass integrated services, applications and extensibility which can be easily adopted and tailored for different disciplines and platforms such as health care professionals, social services etc.

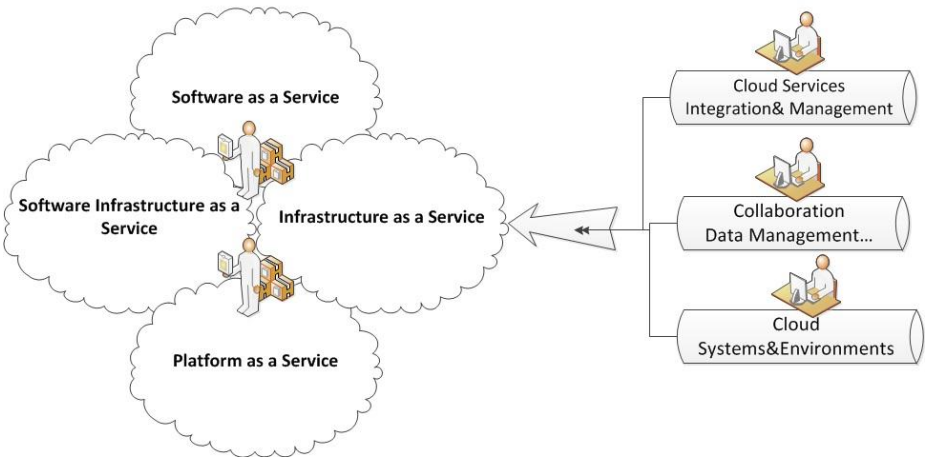

Fig. 1 Service-oriented system operations within the Cloud

The reasons of transforming service-oriented system operations into the Cloud are:

- Cloud systems are automated environments for services and resource sharing. Information of service-oriented system is stored in one or many of the Cloud-based data centres; this data and service information can be easily accessed, backed up,

managed and maintained.

- Cloud computing is also a good choice when dealing with autonomy systems' cooperation, communication, organization and interaction such as cooperative community care. Cloud helps to establish highly effective collaborative and co-ordinated systems to communicate different parities/bodies such as between social services and medical services.

- Cloud computing is good at service assurance. Cloud based system can offer a procedure or a set of procedures intended to optimize operational performance and provide management solutions via communication and networks.

- Cloud computing has gradually been developed to support maintenance activities such as hardware and software applications, tools, techniques and environments. The information extracted from service-oriented systems can be easily transferred into a Cloud-based environment.

- Cloud computing is a cost-saving approach to improve service management and health care practices. It reduces the amount of hardware and software purchased and maintained such as PaaS(Platform as a Service) and IaaS(Infrastructure as a Service)[8]. An effective Cloud infrastructure has advantage to provide client-aware services with ownership and responsibilities by giving updated and optimized options for operations whilst reducing the chance of bottleneck when accessing vital services.

- Secure Cloud access capabilities could help organizations better control access to SaaS [8] applications and to enable a trusted Cloud-based community care environment.

B. Service Oriented System Management with Intelligent Agents

Distributed service-oriented systems are implemented upon an application level software system with corresponding communication mechanism in an open environment. The design of those kinds of complex systems involves an incremental and interactive process. Important aspects of this development include: the need to use system architectures, models and methodologies to create flexible roles, to reach new platforms and to dynamically change relationships among components and services. In business management often refers to the process composed of four classic activities: planning, organizing, leading, and controlling, for accomplishing a goal [15]. Today, as agents become more sophisticated, they need to interact in more sophisticated ways and interactions may require several communications to complete tasks. Each task within a design describes a set of specific aspects of the system under consideration [3, 7, 12]. The agent-oriented systems for e-development require change not only in modification and architectures, but also some models and mechanisms of designing, organizing, accessing and communicating. Agent-oriented software engineering [4] is a practical approach to the analysis, design, implementation and management of such a software agent system, whilst providing the power and expressiveness necessary to support the specification, design and organization of a service-oriented architecture. An approach to the development of an appropriate agent environment is described in which software researchers collaborate with environment builders to enhance the levels of cooperation and support provided within an integrated agent-oriented community system.

Nowadays, many services-oriented applications are based on increasing cooperation and interaction between service provider and related organizational partners. The fundamental design requirement for such systems is that services should be dynamically discovered, integrated and easily accessed, and stored by users, vendors and service providers. Agent-based systems are adopted to associate and help managing services and speed up process in real-world settings. Important aspects of this development include the need to:

- Use agent-oriented architectures, models and methodologies to create flexible roles and management.
- Select platforms and services easily.
- Dynamically change relationships among agents and allocate services via a collaborative agent-based system.

C. Combination of the Cloud and Multi-Agents for Service–Oriented Systems

Results of recent ICT technologies development and Internet blooming, there are far too many interconnected networks, computers, devices, data resources online simultaneously, many of which suffer the underutilization in power, resource finding and communication capability (e.g. bandwidth). For example, a lot of ongoing medical services may request a large amount of computing capacity to complete a computation. The large amount of medical data/record is needed to be used and saved on a unified data centre on a regular basis. The Cloud *on-demand self service* feature [11] would allow agents to pick up services via a server and network without human intervention. The vital health care data and shared resource can be easily accessed by social and health care professionals via networks according to demand; for not longer needed data and old medical record it can be moved and saved in the Cloud with very little cost based on the usage. It will not only save space but also electrical power while reducing the cost of maintenance. Cloud services can be controlled and managed by various intelligent agents in the following ways:

- Cloud Contact Centre with agents can provide fast actions and quick responsive solutions to users via multi-channels.

- Cloud Data Centre with agents can give users an instant accessibility to multi-connected storage with consistent experience via various devices at the same time from anywhere.

- Cloud Services Allocation with agents can set flexible services schedules and plans to individual users which are based on each individual needs and requirement

II. A SERVICE- ORIENTED SYSTEM: CLOUD COMPUTING FOR AGENT–BASED SERVICES IN A COMMUNITY CARE ENVIRONMENT

A. Agent Oriented Software Engineering for Community Health Care Services Provision within the Cloud

In recent years, the providers of public and private sector health care services have been faced with some radical changes in the society they serve [10], and more importantly, development in the way that traditional health care is being transferred to Cloud-based communities. It is predicted by the US consulting company *Markets and Markets* [12] that global healthcare Cloud computing market will be worth $5.4 billion by 2017. Majority health care service applications and service models will be Cloud computing enabled in near future. In health care sector, both private and public, both clinical information (e.g. patient data) and non-clinical information (e.g. accounting) will be migrated into Cloud-based health care systems. The key advantage is that health care professionals and service providers would be able to access Cloud service anytime, via online devices with apps remotely from anywhere in the world. Obviously, due to the sensitive nature of the data, health care service providers and organizations would be most likely to use both public Cloud services and in-house private Cloud services to store and access data and to perform tasks and provide services.

It is widely accepted that better health care results vitally from improved health care services management. This paper considers using agent technology with Cloud approach to provide appropriate co-operative work for the community care domain and to contribute to the community care service field through reorganization of the health and social care services.

Overall in the past decade, the use of multi-agent systems in community care field has been prompted by several evolutionary influences [6]:

- The desire to provide humane and effective care systems that deliver improved services to people, enhancing social interaction and enabling more effective delivery of health care.
- The ability to define high-abstraction level care management strategies by linking the health care professionals into a single framework of accountability. There are many different people or organizations (medical teams, social service, etc.) that are normally involved with different priorities and skills. It is necessary to have a suitable method to allow them to communicate, negotiate, collaborate and cooperate to achieve their common domain goals.
- The development of an in-depth understanding of health information (both the data and its sources), to provide better community medicine, which includes a wide range of the related social services that are often currently neglected.
- Role-based organizational methods allow people to operate with full managerial responsibilities. E.g. established practitioners-community health doctors, senior nurses, medical services planners and health service advisors etc.
- Agent-base care expert systems can assist medical professionals in the tasks of monitoring, detection and diagnosis.
- Cooperative agents can be constructed in a single community to change the human service programme or social service policies, by involvement in planning, scheduling and organizing (both for formal care and informal care services), in a more effective and timely manner.
- The concept of a shared multi-agent environment permits shared supervision and greater teamwork by integrating specialization experts from a number of groups into common service environments. This will allow patients to visit experts, doctors or care organizations by connecting to medical agents though an agent-based community care network within a suitable Cloud-based architecture.

B. Agent Based e-Health Care Services Provision in the Cloud

Community health care is dynamic, complex and progressive [2]. Its aim is to provide such services as necessary to maintain a client's quality of life in the community when they are unable to provide for themselves, thus maintaining their independence. It is also provided by a wide range of disparate, independent organizations and agencies, typically each having their own objectives, of which the provision of community care is only a part. The objective is to integrate this service with their other responsibilities in a coherent and efficient manner [3]. Agent-based community care services are a new approach that automates the process of linking constituents with their core competencies quickly and effectively on the Internet.

Huang et. al. [5] 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 etc. Normally, this kind of medical care service system contains a number of complex mission-critical applications that involve a few types of agents as entities or components working in a common agent environment. In the real world, individual care providers use their own heterogeneous databases, workflows and command and control systems with little or no integration between them [3]. 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. Under the current system an Individual Care Plan is delivered by the Social Services Department of the Local Authority. This department is normally responsible for preparing detailed specifications and services in each case. 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 has their own independent records and command and control structures which are essential components in the delivery of the total package [6]. 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. Researchers in the School of Electronics and Computer Science at the University of Westminster have created a prototype e-medical service system, called INCA Plus (Intelligent Community support for the elderly Architecture) or INCA+.

It aims to improve:

- Current community care systems by using Cloud-based services and agent-oriented engineering solutions to design new cooperative, coordinated, collaborative health care e-services by the adoption of agent-oriented models, platforms and methodologies.
- Coordination between social services and medical care services, organizing and managing these concurrent actions effectively and interpretatively.
- 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.

INCA+ is intimately concerned with agents' cooperation, communication, organization and interaction, factors that represent an effective, coordinated community care system and its associated information systems without loss of autonomy or security. INCA+ provides complex community cares services by using agent technology solutions to organize and allot limited resources and services to a large number of care requirements. From the medical service survey and feedback, it became clear that to maximize the effectiveness and efficiency 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.

III. A PARTICULAR APPLICATION –INCA+ SYSTEM DESIGN WITH CLOUD SERIVES SUPPORT

According to Bacon's adage, "Practice makes perfect", so let us move from agent concepts to the practical design and implementation INCA+ systems' through the use of Cloud Services.

The first step was to analyze all the needs of an agent–oriented community care environment and analyze the requirements with key models, this stage's major task is to identify the roles of agents with related care service resources (includes description and identification of the agent tasks, health services and components). In practice, community care agents in INCA+ system could be illustrated as follows in Table 1.

TABLE 1 THE SAMPLE OF COMMUNITY CARE AGENTS IN INCA+ SYSTEM

NAME	DESCRIPTION
Care Coordinator	The agency responsible for providing the range of services necessary to ensure that the Older person is properly cared for. The Care coordinator is responsible for preparing a Care plan and for monitoring its effectiveness in meeting the needs of the Older person. 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, neighbors 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 older person to remain living at home. This is often flexible and responsive and can range from totally unstructured and so not recognized at all in the Individual Care Plan through to fully recognized and integrated with the efforts of the professional carers.
Older Person	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	It provides appropriate assistances and services during the emergency events. This is often flexible and responsive and through to fully recognized and integrated with the efforts of the professional emergency supports such as Ambulance, Hospital, Fire Service Department etc.. by emergency service operator.

Second stage is to analyze behaviours of overall agents and then put them into a Cloud-based system to provide positive representative roles for each task and health service entity. Each service as an entity can be added, modified and removed as required, providing a very high level of flexibility so that the changing requirements of the user can be met in the most effective manner. Each service agent contains four attributes: *responsibilities*, *permissions, activities*, and *protocols.* The primary goal is to provide high flexible roles by having alternative sources of supply, as illustrated in Table 1. Health care agent *Emergency Services*, its roles can be described as emergency support in response to some unexpected event, such as an accident or medical emergency. This agent also has responsibilities for supply of and negotiation with other agents, such as *Old Person*, through an intensive mix of community support services. The agent *Care Provider* and *Informal Care* provide official and unofficial supports or services as the *Care Coordinator'*s requires. The diagram (Figure 2) shows the part of roles and identifies the domain level responsibilities of health care agents that will require implementation by developer.

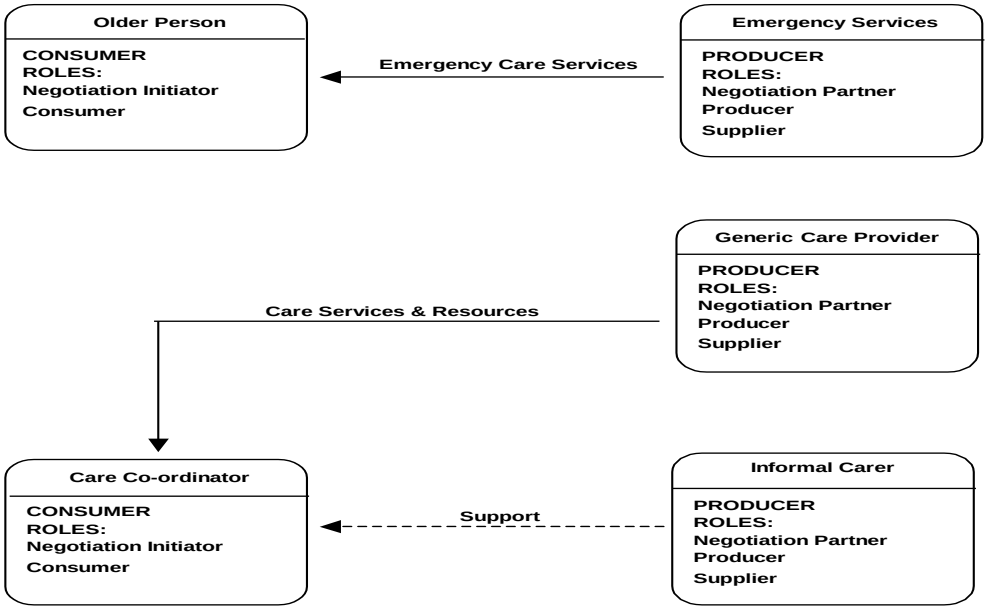

Fig. 2 The participants of the INCA+ agent supply chain

To reduce agent design complexity and identify attributes of each agents (i.e *responsibilities, permissions, activities, protocols)*, we created three models: *agent model, agent services model* and *acquaintance model* which are organized into developing community care environment. Basically, in INCA+ system the *agent model* are constructed agents and their key roles. For example only the agent *Care Provider* can produce planned services for each individual after conforming.

Care Co-ordinator:

```
Care Provider-- Permissions a:
    if ServiceConfirm ( ) = True
    then
       Care Provider ( )
       {
          Read supplied ( )
          {Customers requirements
           Care services Process
           Care Planning Scheduling …
  }
       Generates ( ){Provide Care Services }
Monitoring( ) {Service Progress}
Etc..
}
```

The *service model* and planning contains a set of service plans and tasks for elderly people's needs and agent *responsibilities* of this *service model* could be described thus:

Care co-ordinator's activities:

Plan 1: The agency responsible for providing the range of services necessary to ensure that the older person is properly

cared for.

Plan 2: This agent is responsible for preparing a care service individual plan

Plan 3: Care services scheduling and cooperation with formal and informal care agents

Plan 4: For monitoring its effectiveness in meeting the needs of the older person

The following figure is an example (Figure 3) of care service routing, which shows that both official and unofficial care producers/agents (such as *Care Provider*, *Inform Care*, *Care Coordinator*) could provide an individual care plan and community care services for older person through negotiation.

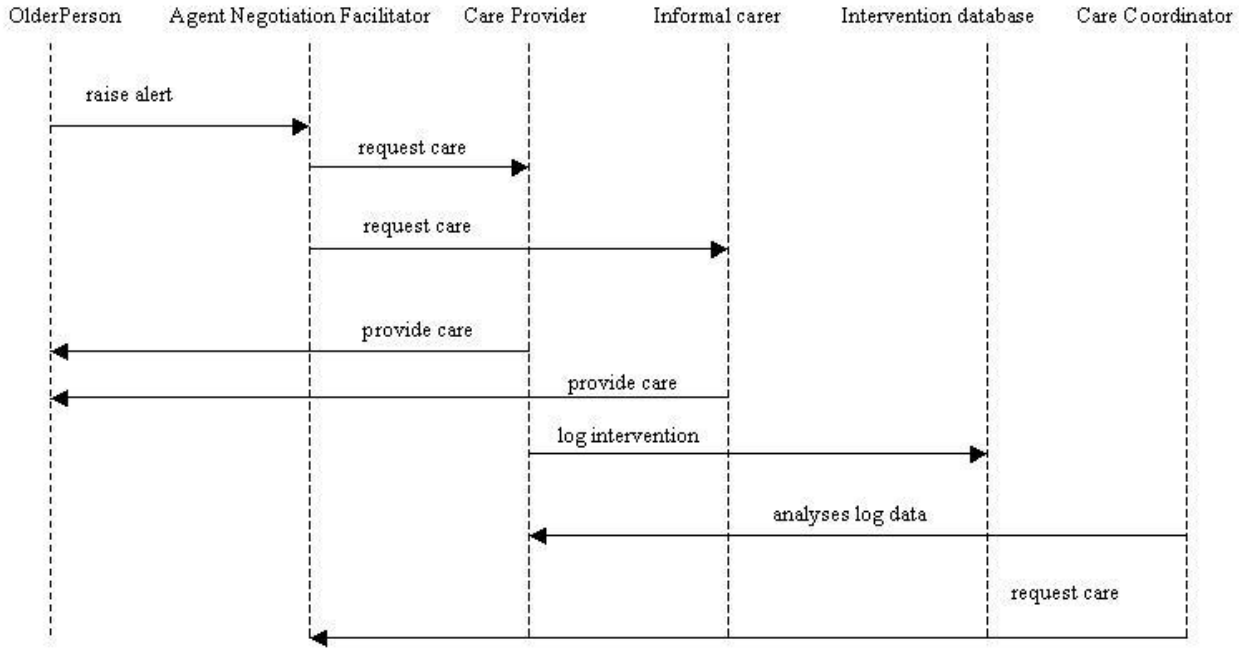

Fig. 3 An individual care plan and communication routing for older person

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 and negotiation rules among agents). Furthermore, *protocols & activities* attributes have been mentioned above. The modelling represents the technical roles via communication that allow knowledge-level agents to be linked efficiently and to share and exchange resources in a common agent architecture. Such interactive community care supply routing can be seen as follows (Figure 4):

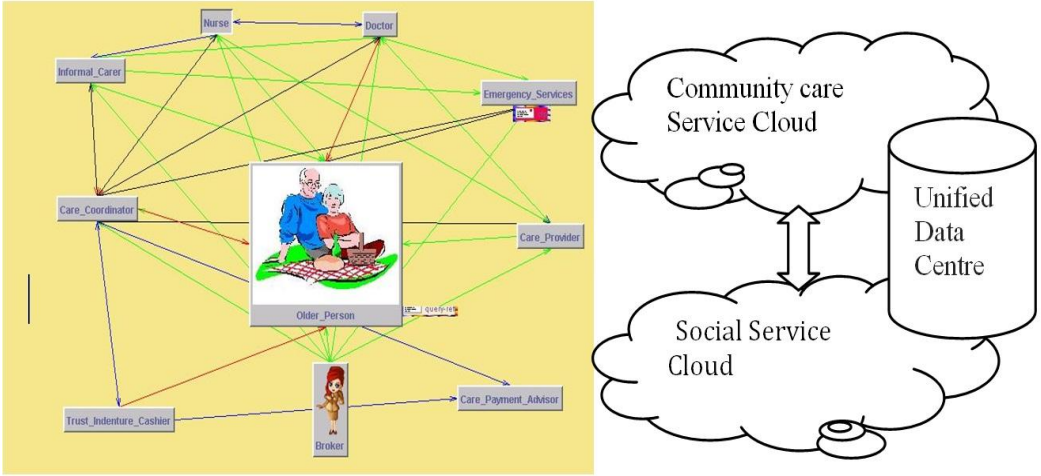

Fig. 4 Community care service control and management via message passing and interactive routing.

The final stage is to transfer agents to a public or private health care Cloud, which involves adopting and intergrading Cloud infrastructure, platform, storage/data centre, software applications and services. This Cloud has a range of responsibilities such as save record/data, provide services, control and manage agents and charge fees etc. It can be illustrated as follows in Figure 5:

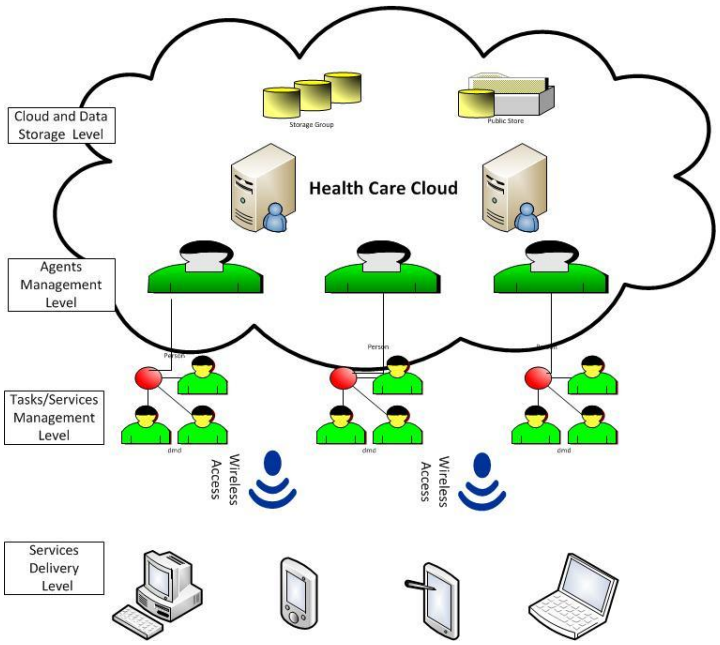

Fig. 5 Community care service control and management via Agents in the Cloud

IV. THE BENEFITS OF USING AGENTS AND CLOUD COMPUTING TECHNOLOGY FOR SERVICE-ORIENTED SYSTEMS

Through studies of the INCA+ agent development process we have found that the utilization of Cloud services is a step in the right direction for the future development of INCA+.

Agent-oriented community care, such as INCA+, unveil a tremendous range of challenges and opportunities to create more advanced distributed e-service systems by fully using agent availabilities and responsibilities, allowing us to open our minds to face more powerful visions of agent-based information systems and to open the door to new service styles which lead to reduced costs, improved communications and so affect the way we live, work and do business.

The main contribution of Cloud computing technology and Cloud-based services to INCA+ work is the attempt at making the development and support of Multi-Agent System as easily as possible via Cloud platform, hardware and software, and services while saving operational cost. It greatly simplifies the configuration and organization of agents, the endowment of communication with greater capability as well as cooperation capability of agents. It also fields real-world problem intelligent generative processing and system functions, settings in an open environment in the Cloud. So suitable Cloud-based collaborative agents for community care can be easily reached and designed in the following agent-based architecture [Figure 6]:

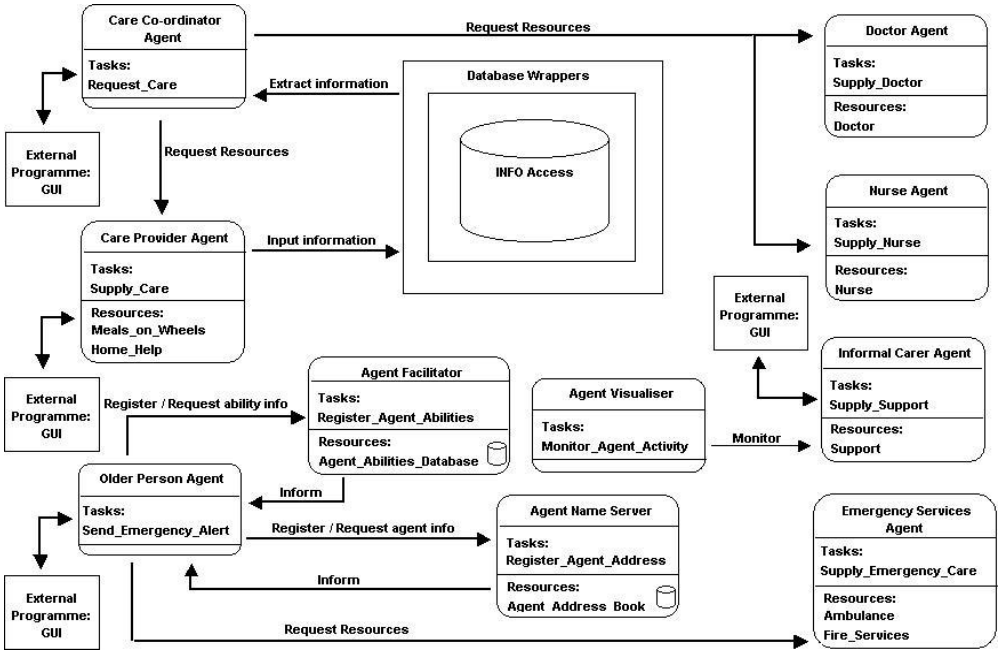

Fig. 6 Service-oriented architecture of the INCA+ for service control and management

In summary, the adoption of Cloud computing in cooperation with practical agents for services control and management has given positive characteristics including:

- **Inferential capability**: The ability to act on roles and tasks specifications from perception model to action and provide flexible services. It is able to provide a friendly platform by integrating cooperative agents and services into a Cloud-based environment.
- **Operational ability:** Cloud system offers the most of infrastructure, platform, hardware and software for operation. The Cloud end user only needs to define all variant and invariant roles of each agent and describe agents' attributes and dynamically organizing conditions for operations.
- **Structure adaptable:** Its modelling and structure are terse, the system is easy to discover and reconfigure via agents to real-end user requirements, to enable re-usage of model, components and structures.
- **Communication ability:** Agent interconnections and interactions via a common interface within a Cloud, all the data store; back up and maintenance happens instantly.
- **Scalable system support:** It offers a set of powerful functional methods to expand the support capability and provide proactive agent services knowledge level system management with highly-flexible agent architecture.
- **System Security Assurance:** Cloud computing offers better technical assurance to secure agent-based systems within the Cloud with minimal administrate effort.
- **Technology driven continued development and extension ability:** As Cloud business vendors and providers have to offer more and more reliable Cloud-based platforms and services to customers, further opportunities and extension abilities will appear along with technology development.

V. DISCUSSION AND CONCLUSIONS

From the "research and development" point of view, the organizations that adopted Cloud would be able to work in a more flexible ICT environment in the near future. The Cloud platform and its framework cover a wide range of possibilities for better performance, such as up-to-date applications, responsive usage of services and task changes, uninterrupted administrations, shared data/resources, cost saving, etc. The Cloud services will require solutions for many technical fields such as applications, network infrastructure, servers, storage and operational policies, etc.

For service-oriented approach [18] to agent systems development (e.g. community care service provision), there will be many fresh Cloud-based services created, reconfigured, reconstructed and cooperated within a coherent Cloud-based environment. The case study in this paper shows using Cloud technology and services-oriented architecture to manage INCA+ project development is a right combination for future research and development. The usage and adoption of Cloud technology, service-orientation and agents to provide, control, operate and manage ICT resource and health care services is an effective way for application development. Therefore, connecting Cloud-based services with agents is a good solution for domain modelling. It also greatly simplifies the configuration and organization of agents and the endowment of communication capability as well as cooperation capability of agents-based services. Cloud computing with intelligent agents to support service-oriented system is a good solution for multi and cross-domain environment control and management.

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