Some Observations on the Use of a System of Agent Communication

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Abstract

In this paper some observations about the use of the FIPA specifications in a number of projects are made. A particular interpretation of these observations is presented and some suggestions as to the impact that this should have on Agent standards is given.

1. Introduction

This paper presents some information on the use of FIPA technology [1] during the Agentcities projects [2]. A particular interpretation of this information is made and a set of suggestions for future directions is made.

The scope of this paper is to report on the general use that was made of the FIPA communications standard by a diverse community of developers who were provided with an opportunity to experiment with this technology. The paper does not attempt to evaluate any of these projects. In particular the paper should not be construed as making a technical or commercial judgment about any particular project or the projects as a group.

2. The FIPA Model of Agent Communication

FIPA is the Foundation of Physical Agents and has existed for 5 years, its mission is to provide specifications that enable agent systems to interoperate. There are 96 FIPA specifications which have been developed, these are at various stages of development. The milestones of the FIPA process have been FIPA-97 and FIPA-2000 and developers often refer to these milestones to indicate the version of the specifications that a particular toolkit or application conforms to. In 2002 FIPA voted to make a subset of the specifications "standard". This move indicated that the specifications in this group would be stable for a considerable period of time. 25 specifications have been classified as "standard" status.

The process of incremental improvement and debate in FIPA has resulted the evolution of a sophisticated and relatively complete standards set. During this process some basic technical premises have remained constant.

A set of "communicative acts" have been described by FIPA. These communicative acts are "speech acts" they are used to denote the intention which motivated an Agent to send a particular message containing particular data. For example the utterance "writes (someone, paper)" could be interpreted as meaning "I am *informing* you that someone is writing a paper" or "can you tell me if it is true that someone is writing a paper" or "someone, please write the paper that you promised". A communicative act is a tag which distinguishes the meanings between these messages according to some tightly defined semantic, which the FIPA specifications contain. The standard FIPA specification SC00037 defines 22 communicative acts. KQML [3]. is an example of another effort which has attempted to define a set of performatives that should be used by agents to enable message interpretation.

The communicative act tags a message, but the content of the message itself must be defined. A content language defines the grammar of expressions that can be used. The terms that are used in expressions are defined within an ontology; which is itself a set of expressions which relates a number of terms together. In this way a term's membership of an ontology places it in a context with a set of other terms.

Protocols which describe expected sequences of messages between agents are used to facilitate the co-ordination of the exchange of information in predefined scenarios. Examples of messaging

protocols are the sequence of exchange of information that participants in an auction use to exchange information on the value of a good. FIPA has defined 11 protocols. The space of possible auction protocols has been analyzed [4] [5]. Other communities [7]. have developed alternative approaches which use declarative and descriptive approaches to defining message meanings.

3. Data Gathered.

In this section we present some data on the use of the FIPA technology made on the Agentcities Network.

We have obtained data from two sources.

- A survey of data of services registered on the network.
- The corpus of documentation delivered by funded Agentcities.NET projects.

This data is presented below.

3.1 DF Survey data

Data was collected from the Agentcities DF by inspection over several days in late June 2003. T

Information was gathered by counting registrations and by inspecting services to ensure that they were live at the time. Where a known error in registration was identified this service was excluded[1] In addition all ping agent registrations were excluded. [2] In some cases services were duplicated by multiple registered instances; several restaurants or cinemas for example. In this cases we counted the service type only once.

In addition to examining the registrations services that were identified were also cross checked against any interface descriptions that had been published in order to find any descriptions of non-protocol interactions available.

Where it was known that a service implemented a protocol it was assumed that it implemented all the performatives required to implement the route through the protocol.

It should be noted that registration of service data is not necessarily a accurate source of information. There are at least two cases where it is known from subsequent information that the services registered supported a more sophisticate interface than was apparent from the registration.

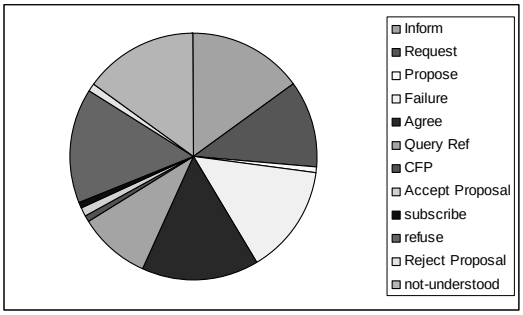

Figure 1. Proportion of communicative act types used from DF survey

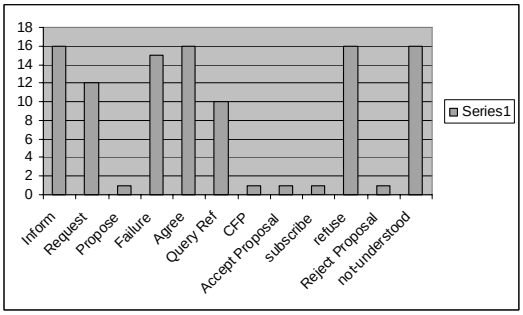

Figure 2. Relative numbers of reported use of communicative act type from DF survey.

The key features are :

- Only 12 (from 22) communicative acts are observed as used.
- Only 7 (inform, request, failure, agree, query-ref, refuse and not-understood) are used frequently.

[1] In this case Zeus hosted services from the Adastral City platform were excluded because they contained a default registration which did not reflect their true properties. This was caused by the fact that Zeus agents are equipped with a default iterated-contract-net whether or not it is required.

[2] Ping was the liveness service that platforms had to implement to be considered to be on the network.

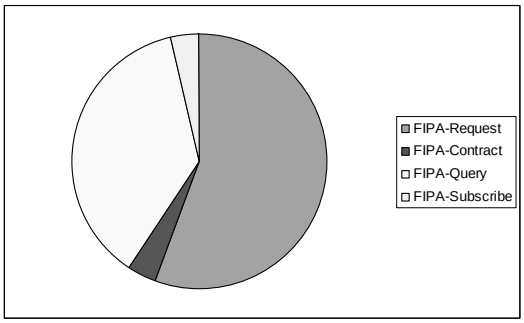

Figure 3. Proportion of use of protocols from DF survey

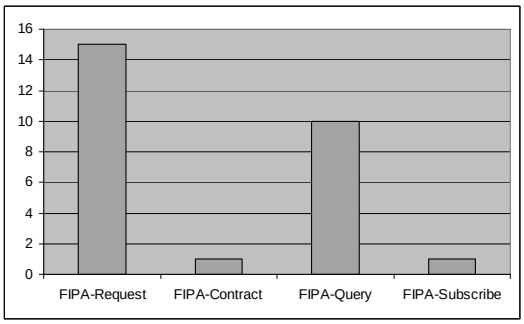

Figure 4. Number of reported use of protocols from DF survey.

4 FIPA protocols[3], from 11 were reported as used.

It should be noted that on inspection it was felt that a number of services implemented data query interfaces using FIPA-Request.

3.2 Documentation Inspection

A corpus of project reporting documentation has been assembled from projects in Agentcities.NET. Many of these documents report and document elements of the interfaces that were developed. This information has been used to prepare the data presented in this section.

Again it is important to note the deficiencies of this data gathering method. Firstly, unfortunately no documentation standard was established for these projects. Consequently a number of projects were documented from project management or user manual points of view; these projects had to be excluded. Some projects were purely technical in focus, for example the funding was used to develop visualization and management interfaces or other tools. These had to be excluded as well. We also note that even where extensive documentation of service interfaces was available this was provided by the authors with the intention of describing what they thought was significant about the work that they had performed. Of course elements of the service interfaces may have been left undocumented because they were not the core of the project.

Finally because this was a survey based on inspection of a corpus of documents it relies on personal interpretation. While every effort was made to make a thorough and systematic job of inspecting and interpreting the information available inevitably the data will have been distorted by its transition.

The documents were used as follows. The documents was searched from any reference to any communicative act or any protocol. This was done by using the search facility of acrobat or ms-word depending on the document format. The document was then inspected by eye to check that nothing had been missed. If we discovered a reference we marked it as used or understood by the service.

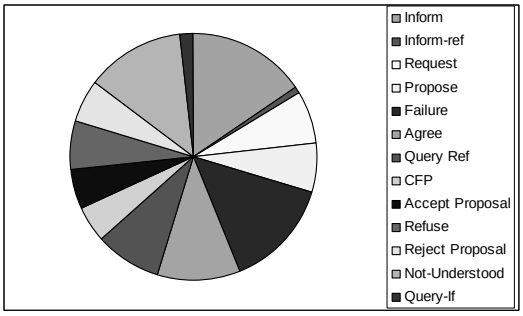

Figure 5. Proportion of use of communicative acts from documentation.

[3] Although we observed the use of a subscribe protocol we could not find any reference to the use of the cancel meta-protocol; so we did not record it as being used.

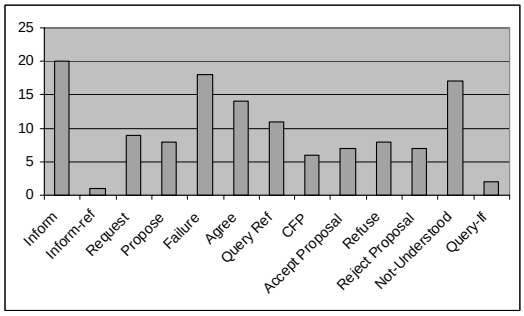

Figure 6. Number of usages identified per communicative act from documentation.

The picture assembled in Figure 5 and Figure 1Figure 6 is somewhat different from the picture observed from the DF survey. Their appears to have been more emphasis on contracting in the projects reported in the corpus and this has caused a relative increase in the number of uses of contracting communicative-acts (CFP, Accept-Proposal, Propose, Reject Proposal).

In addition there were some reports of ad-hoc use of communicative-acts; requests and informs that were not part of complete protocols.

13 communicative acts appeared to have been used, but in this case no subscription service was observed. There was a report of a Query-if communicative act and a report of an Inform-ref act.

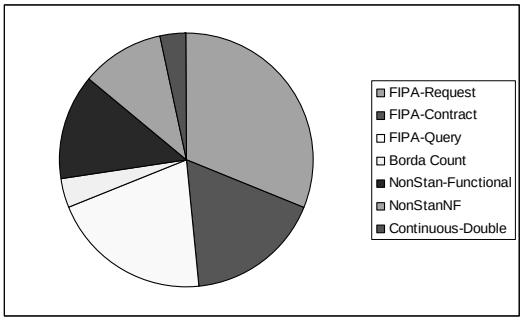

Figure 7. Proportion of use of protocols from documentation.

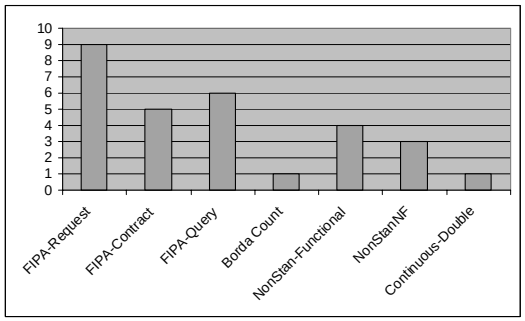

Figure 8. Number of reports of use of protocols from documentation.

In Figure 7 and Figure 8 it can be seen that a wider range of protocols have been reported as used including a number which are not part of the FIPA standard. Borda-Count has been developed as a suggested part of FIPA, however it was noticeable that several groups implemented a bespoke access control protocol in addition there was one implementation of a protocol aimed at performing a domain specific task. However, even accounting for these differences it is noticeable that request and query protocols dominated.

4. Discussion

4.1 General Comments

We can see that the most significant use of FIPA technology in Agentcities was for the implementation of request and query services.

To a lesser extent the technology was used to implement simple contracting services. Just one use of publish and subscribe information transfer was observed.

It appears that pull services (request, query, call-for-proposal) dominate push services (inform, propose).

We also note that the only open contract formation system that appears to have been used widely is the contract-net. One instance of a continuous double auction was described. Auctions were implemented by agents in the network, but they were not done using FIPA-Protocols openly. Instead specialist agents (brokers) were contacted via request protocols by suppliers or requestor agents in order to register goods or request goods. The reason for this seems to have been a perceived need to establish trust relationship between provider and requestor which enables funds to be transferred. This was reflected in the number of attempts to implement

access control protocols both as specific custom protocols and as variants on FIPA-Request.

In our data there appears to be a close relationship between the protocols that were implemented and the range of performatives that were implemented. This correlation is stronger in the data from the df. This is suggestive of the use of protocols in a stove-piped fashion by developers, but could be an artifact of the data gathering methods that we used in that we assumed that the service would utilize performatives associated with a protocol if it declared that it could use the protocol.

4.2 Surprises & Issues

There are three Inform communicative acts specified by FIPA; we only observed the use of one widely (inform) and one use of inform-ref . This may be because there is an apparent confusion in the FIPA specs on this issue. SC00037J refers to inform-ref as the correct communicative act to return a reference to a specified descriptor. While the request protocol SC00026H refers to inform-result and inform-done; it is not clear that an inform-ref is the required act when inform-done presumably refers to an inform message that contains the content “done”.

5. Suggestions

5.1 Separation of concerns with respect to communicative-acts.

Some simple actions and improvements to the FIPA standards are suggested from our observations.

The complexity of the standard could be reduced by reducing the set of communicative acts sharply.

Cancel, Refuse, Reject-Proposal, Disconfirm and Failure are all defined to be semantically different, but are the differences sharp enough in the mind of the average developer to actually be a motivation for using them as they were intended?

In the same vein, Accept-Proposal, Agree and Confirm all seem to have similar meanings, and the shades of differentiation do not seem adequate reason for their inclusion.

Proxy and Propagate seem to be different in intention from most defined communicative acts in that they are intended to be used to control communication as opposed to effecting the Agents mental state. An alternative to these communicative acts would be to define a non-functional protocol for transmission control using the request and inform communicative acts and the semantics of a content language.

Multiple groups appeared to attempt to implement access control using the FIPA-Request protocol. In the same spirit as above we could suggest that a specific protocol for access control should be specified using request and inform communicative acts. Alternatively if specialist non-functional communicative acts are to be included in the communicative act library then perhaps login/logout acts should be introduced.

Any access control mechanism that is developed could be applied to the directory infrastructure elements (DF/AMS) to overcome the need to provide specialist authentication middle agents to support particular information propagation mechanisms in applications; for example reliable pricing information.

An explicit design decision with respect to the communicative-act library needs to be made. Communicative-acts should be provided for the functional business of programming agents; the exchange of information and the formation of joint intention. Other communicative acts should be available in the context of defined non-functional activities; the control of the transmission of information in the network or the control of access to resources.

5.2 Generic Protocols

The FIPA-Contract-Net appeared to be the only FIPA contract formation system used in the network. Non standard systems were also implemented, but there are two problems. Firstly the other FIPA contracting protocols (English-Auction, Dutch-Auction) are call-respond type protocols and in-fact similar in nature to contract net; why were they not used? Secondly non-standard protocols are a barrier to interaction.

The FIPA definitions do not include the specification of non-functional parameters such as number of iterations, time to complete deal,

length of auction. Given the vast space of auction types and scope for parameterization it might be more appropriate to provide a mechanism for the definition and declaration of protocols, as opposed to the provision of a catalogue that will always remain incomplete. In addition the choice of when information is revealed in a dialog and who will reveal it is highly sensitive in terms of the risk allocation and the likely clearing and pricing properties of the interaction. Individual applications need to be constructed with regard to this, but for interactions to be truly open in nature they also need to document the mechanics of the interaction to enable system integration.

One approach to this is to develop an interaction pattern language that enables the documentation of interaction protocols suitable for particular uses [6].

5.3 Application Drivers

FIPA has identified and documented a number of applications : Personal-Travel-Assistant; Audio-Visual-Entertainment; Network-Management & Personal-Assistant. Also documented are nomadic application support, software integration, message buffering and quality of service. These documents do not appear to actually report applications, but instead infrastructure elements that might be useful to support some classes of applications (for example applications in which quality of service is important).

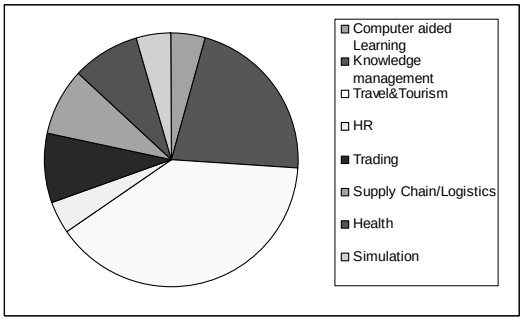

Figure 9. Application of accepted Agentcities.NET projects

In Figure 9 the distribution of application areas for projects run in Agentcities.NET is shown. Obviously categorization of projects in this way is problematic, subjective and prone to error, but the overall distribution shows clear trends. We also note that these projects were proposed and selected as the result of a call which named certain application areas of interest.

The largest category by far was travel and tourism centered projects. These are similar in spirit to the FIPA Personal Travel Assistant application, but often groups focused on some particular element of the application such as providing a restaurant booking service. In addition the Agentcities.RTD scenario which was developed explicitly to test advanced agent concepts was focused on this domain.

We observe that :

- The example application use cases that are available (with the exception of the Network Management case) do not adequately motivate the use of Agent technology. The technical advantages must be more explicitly articulated in order to motivate developers to utilize them in the expected fashion.
- The example application use cases that are available are not strongly focused enough on particular domains or business cases. For example, there is a conflation of the ability to book a meeting and book a business trip in the personal assistant example. No clear business models for the actors in these scenarios are clarified. Clear USP's and benefits in particular domains must be articulated for these applications to serve as useful examples.
- Model application use cases need to be constructed that illuminate the use of Agent technologies in Supply Chain management and Logistics; Healthcare and Trading.

The development of mature, fully implemented, properly documented and compelling case studies such as those listed above will provide clear motivation for the full utilization of the technology specifications that support them. In addition this kind of activity will provide the drivers that will enable the community to prune and focus standards sets, further facilitating uptake.

The following criticisms of the work we have presented can be made.

6. Evaluation

1. *The projects surveyed here were pioneers of agent technology; in the future more sophisticated implementations will use the FIPA model more differently*. Clearly there is a process of education and knowledge development which will influence the use of agent standards in the future. Very few of the developers that have developed Agents in Agentcities will not have learned from their experiences. It is important that technology is as accessible as possible and it would be wrong to expect widespread uptake of technology that requires developers to work so hard to become expert in.

2. *These issues are not the product of the FIPA model, they are a product of the toolkits that were widely used in the Agentcities network.* Multiple toolkits were used in the projects, developed by many diverse groups. These implemented a variety of agent models from BDI to very lightweight and it seems that this diversity counters this argument.

3. *The projects that are included are too small scale for any inference about the utility of the approach to be made*. It is true that the services surveyed were generally developed over short timescales. Because of this it is correct that this picture may not reflect the true use of these technologies in live engagements. In addition anecdotal evidence suggests to some extent this is the case with a number of commercial agent applications apparently resting on sophisticated contract formation functionality in closed intranet settings.

4. *Not enough data is provided; this sample is too small*. This is the first opportunity to make a study of this sort, it would have been preferable to obtain more information from a wider range of projects and perhaps in the future others will be able to do so and to highlight any deficiencies in our evidence.

5. *This is pseudo-science the evidence is so weak that it proves nothing*. This is a serious criticism of this work, what is presented here is an attempt to gather and interpret some evidence in order to stimulate debate and suggest future directions for work. In a truly scientific study the evidence could also be gathered by others and the measurement repeated, this is not the case here, however it is to be hoped that similar studies could be performed in similar situations in the future. It is also noted that here we are examining human behavior, not measuring a natural system, and by examining and publishing this evidence the behavior of the humans in the system may well be changed in some way. Like all social science asking the question can change the answer.

7. Conclusions

If FIPA didn't exist the Agent community would have to invent it; we would have no standard technology to investigate and critique. The FIPA specifications have enabled the development of a large number of applications and their deployment in the Agentcities environment. Agentcities was successful in providing an open environment that did not rely on a particular toolkit, or the development of new toolkits that was used by dozens of groups to deploy and interoperate services. Without the FIPA specifications it would not have been possible to do this, and so it would not have been possible to make any attempt to understand how the technology that FIPA uses would be exploited by users.

In this paper we have presented evidence of the characteristic use made by developers of these standards and this has highlighted some possible paths for future development. In particular we have highlighted the need for a separation of concerns in the communicative act library; the need for more flexible protocol design and more systematic protocol documentation and the need for enhanced application drivers for the specification.

Technology development is a dialog between users and technologists; research and industry. Ideally future projects will measure the characteristics of the use of the technology that they utilize more systematically and be able to report with more confidence than we are able to.

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