Using Agents to Support Negotiation in Video-on-Demand Services

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Abstract

The widespread availability of high-bandwidth networks is promoting the development of high-quality video-on-demand services. These services require efficient and flexible resource-management techniques to satisfy the customers' needs. These techniques are based on the possibility to allow customers and providers negotiating the parameters that characterise the service. This paper describes how agents can be used to support price negotiation when the provider can lower the price as the number of customers grows. The added value of using agents for this task is that customers and providers are not directly involved in the negotiation. They simply tell their agents the desired parameters and let them autonomously find an agreement.

1. Introduction

Resource reservation is considered one of the most important factors promoting the success of video-provision services over the Internet [2]. The new service models, such as video-on-demand (VoD), need flexible and efficient resource-management techniques to allow the customer taking part actively in the provision process. In fact, these models extend the consolidated pay-per-view model to provide customer-oriented services. In the pay-per-view model the provider completely controls the network traffic and customers do not interact with the provision system. More recent service models, such as VoD, allow customers controlling the provision system. These are more critical regarding the employed resource-management techniques because the provider has not the complete control over the network traffic. At the moment, there are two different forms of VoD: the VCR model and the near video-on-demand model (NVoD) [1]. The VCR model is completely customer-oriented as the service provider allows each customer exploiting VCR-like features such as pause, rewind and fast forward. This model requires that the provider assign a high-bandwidth channel to each customer thus making costs linear with the number of customers.

The NVoD model is an evolution of the VCR model intended to limit the provider costs and the bandwidth requirements. The same video is transmitted on a pre-set number of channels concurrently and each video has a different start time. The start times are placed at regular, and small, intervals. As an example, the provider might decide to transmit the same movie every 10 minutes between 8pm and 9pm. This would allow the customer choosing not only when to start watching the movie but also it would support moving forward and backward in the movie shifting between channels. If the number of customers watching the movie is higher than the number of concurrent channels, the provider can fix a price lower than the corresponding in the VCR model while keeping similar features offered to the customers.

The NVoD scenario comprises two variables affecting the provider's profit and costs: the number of customers and the number of channels. This suggests that a negotiation process could be useful to find an agreement between the provider and the customers on a price for the provision service. This paper describes how agents can be used to negotiate the price for a NVoD service when the number of channels is fixed. Section 2 describes the reference scenario considered while developing the presented agent-based negotiation algorithm. Section 3 describes this algorithm and explains the reason why the standard FIPA protocols are not suitable for this scenario. Finally, section 4 comments on the presented work and outlines some future work.

2. Reference Scenario

The work presented in this paper starts from a concrete reference scenario related to the CNR Applied Research Project 5% "Multimedialità". One of the goals of this project is to realise a passive optical network to allow users establishing high-bandwidth connections with a video server. The cost of NVoD services over such a

network is nearly independent from the number of users and therefore the service provider can accept to lower the price as the number of customers grows. This suggests using autonomous agents to negotiate the price for a video without involving users in the negotiation process. Such a scenario requires, at least, two types of agents: service-provider agents and personal agents [5, 6] acting on behalf of users. Figure 1 shows the agent architecture needed to support this scenario.

The reference scenario starts when a user comes to know that a movie she is interested in will be transmitted between 8pm and 9pm that evening. The user requests her personal agent to retrieve information about that showing from the service-provider agent and, on the basis of this information, she decides to watch the movie. The user informs her personal agent of this decision supplying the limit price she is willing to pay for the movie. This price is set by the user on the basis of a suggested price proposed by the service provider. The personal agent uses this price to drive the negotiation with the service-provider agent and keeps it secret to allow for a fair negotiation. This initial step of the reference scenario finishes when the personal agent informs the service-provider agent that its user is interested in watching that movie.

A few minutes before 8pm, the service-provider agent knows the number of users willing to watch the movie and it starts the real price negotiation with the interested personal agents. It proposes a first-guess price to the personal agents and collects the acceptances and refusals. A personal agent accepts a price if it is lower that the limit price set by its user and rejects it otherwise. If the number of acceptances satisfies the service-provider agent, it closes the negotiation, otherwise it lowers the price and iterates the process proposing a new price. This price lowering allows more and more personal agents accepting the price and therefore it potentially increases the service provider's profit. The negotiation finishes when the service-provider agent fixes a price for the movie, or when it decides to drop the showing, as the price is too low to compensate the costs.

When the service-provider agent succeeds in fixing a price for the movie, it tries to propose that price also to personal agents that refused it during the negotiation. This allows personal agents proposing this fixed price to their users as a final chance to watch the movie. The user might accept this price or not and if she accepts it, her personal agent informs the service-provider agent of this decision. This step concludes the negotiation and the service-provider agent informs the video-provision system of the list of users who accepted to buy the movie.

The use of agent simplifies the interaction between the service provider and the customers as they are only requested to provide a limit price leaving agents the complete control of the negotiation.

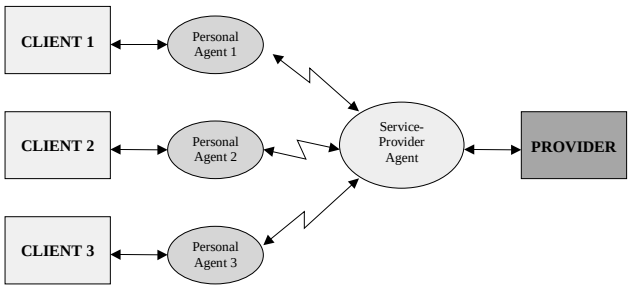

Figure 1. Agent architecture.

3. Agent-Based Algorithm

One of the peculiar features of agents is their sociality, i.e. their ability to interact to pursue common or competitive goals. FIPA, the Foundation for Intelligent Physical Agents [4], tries to actively support agent sociality recognising that a way to ease the modelling of interactions between agents is to exploit interaction protocols. While each FIPA ACL performative is given a formal semantic based on the speech-act theory, FIPA provides a set of interaction protocols to support complex interactions composed by many messages. FIPA distinguishes between generic interaction protocols, specified in the approved ACL specification, and domain-specific interaction protocols. The latter protocols can be used to support domain-specific interactions and FIPA suggests three requirements that should allow validating these protocols.

FIPA basically provides four generic interaction protocols to support negotiation between agents [4]. The FIPA contract net protocol [3, 4, 7, 8] involves an agent, called the manager, and a set of agents called contractors. The manager uses this protocol when it wants an action to be performed but it does not know an agent capable to perform this action. The manager initiates the protocol sending a call-for-proposal message to all other agents. Some agents, i.e. the contractors, answer to this message with a proposal. This proposal declares the capability of the contractor to perform the requested action. The proposal is completed with a description of the constraints, in terms of the price or the quality-of-service, that rule the contractor in accepting to perform the action. The manager evaluates all the proposals and selects a contractor on the basis of them. When a contractor is selected, the manager sends an accept message to it to end the protocol. The FIPA iterated contract net protocol can be used to refine the proposals received in a contract net protocol because the manager can refuse all proposals and issue a revised call for proposal. This protocol ends when the manager accepts a contractor, when all contractors refuse the call for proposal or when the manager stops the protocol refusing all proposals. The FIPA auction English protocol resembles an auction for selling goods according

to English style, i.e. a low initial price rises gradually until a client declares its intention to buy. The FIPA auction Dutch protocol realises the Dutch style for auctions, i.e. the auctioneer starts with a price much higher than the real market value of the goods, then she lowers the price gradually until one of the clients accepts the suggested price.

The reference scenario described in the previous section suggests the interaction protocol that agents should follow to negotiate the price for a video. This protocol should allow agents to perform an iterated negotiation where the negotiated value, i.e. the price, is refined only by the single service-provider agent. This is the main reason why FIPA generic interaction protocols, cannot be applied. The FIPA contract net protocol and its iterated variant comprises one manager and a set of contractors. The manager solicits proposals from the contractors to have some task performed. Then the manager "evaluates the proposals and makes its choice of which agents will perform the task" [4]. This protocol cannot be applied because the roles played by agents are opposite to the ones played in our reference scenario. In fact, the reference scenario depicted in the previous section requires various managers, i.e. the personal agents, willing to buy a service and only one provider offering it. Only the service-provider agent knows how many agents are involved in the negotiation and how to modify the preconditions of the proposal. Moreover, personal agents do not perform a private negotiation with the service-provider agent, but they co-operate to reach the goal of minimising the price.

The FIPA auction Dutch protocol seems to fit our reference scenario when allowing the service-provider agent to play the role of the auctioneer and the personal agents to play the role of buyers. Anyway, it cannot be used because the personal agents do not make bids but they only accept or to refuse the proposals. Moreover, the behaviour of the service-provider agent is not intended to reduce "the price until one of the buyers accept the price" [4]. On the contrary, it prefers to lower the price to increase the number of customers. Besides, the protocol suggested by our reference scenario does not terminate when the price is closed because the service-provider agent tries to sell the movie also to the users that refused it during the negotiation.

FIPA specifies some other interaction protocols to manage direct interactions, such as the FIPA request whenever protocol, and brokering. Besides, these protocols are not meant to support negotiation and therefore they cannot be used to implement the scenario depicted in the previous section. The differences with all generic interaction protocols proposed by FIPA suggest introducing a new protocol. The remaining of this section describes this domain-specific interaction protocol and figure 2 shows its state diagram.

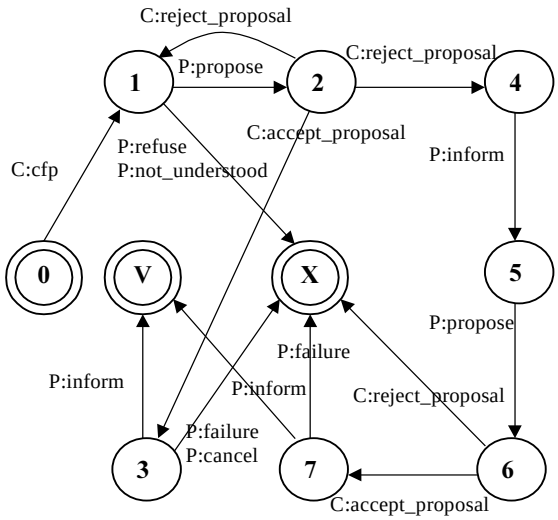

Figure 2. State diagram of the proposed interaction protocol.

The protocol starts when the personal agent sends a call-for-proposal message to the service-provider agent. This message informs the service-provider agent that the personal agent is interested in negotiating the price for a particular showing. This message does not contain the limit price fixed by the user. Just a few minutes before the showing starts, the service-provider agent decides to negotiate the price refusing any new call-for-proposal. The protocol is continued by the personal agents and we call:

C : The cost that the provider must face to transmit the video. We consider this cost fixed.

P_{min} : The minimum profit that the provider decides to earn.

$p_{i,max}$: The limit price for the personal agent A_i.

n : The number of call-for-proposal received by the service-provider agent.

p_{init} : The first-guess price fixed by the service-provider agent. It must satisfy: $(n \cdot p_{init}) - C > P_{min}$.

These values allow the service-provider agent starting the negotiation or refusing to start the showing if it estimates that n is too low to compensate the costs. In the case that the service-provider agent continues the negotiation, each personal agent A_i receives p_{init}. This message contains also the deadline for the reply that each A_i has to meet to be accepted for a further negotiation step. If A_i decides to accept the proposal, i.e. if $p_{i,max} \geq p_i$, it sends a reply to the service-provider agent to inform it of its decision. This message implicitly states that A_i will accept any fixed price lower than p_i. Once the service-provider agent has received all the replies from the personal agents, it evaluates its current profit as

$P = (p_{init} \cdot n_a) - C$, where n_a is the number of acceptances received. The algorithm iterates with the service-provider agent proposing to the remaining $(n - n_a)$ personal agents a lower price, until:

1. $P \geq P_{min}$ and the profit begins to decrease. This fixes the final price.

2. The final deadline for the negotiation is missed and the showing must start.

3. $P < P_{min}$. The service-provider agent drops the showing because the profit is lower than the minimum accepted.

In the first and second cases the service-provider agent informs the personal agents of the fixed price and it allows the personal agents that refused that price accepting it without a further negotiation. In the third case, the service-provider sends a cancel message to the personal agents that have accepted its proposal. Then, it may decide to start a new negotiation lowering the quality-of-service offered for the showing. This allows lowering the price, but requires the protocol to restart completely. Figure 3 shows an example of the protocol.

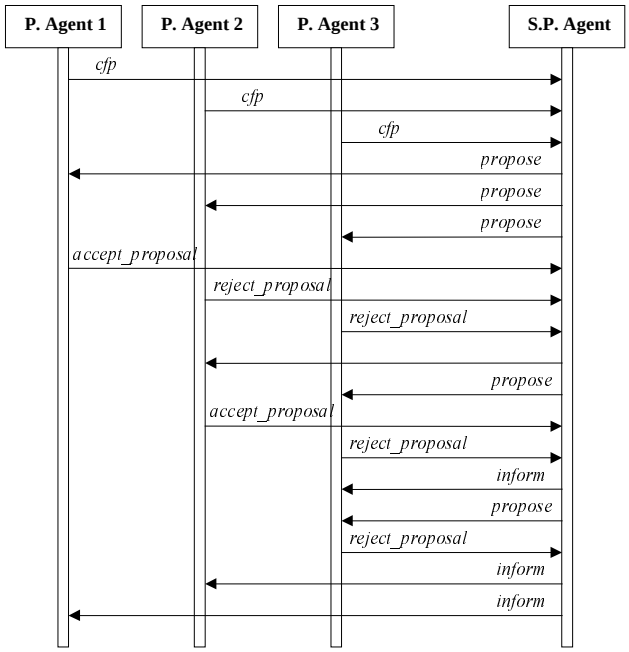

Figure 3. Sequence diagram of the proposed interaction protocol.

4. Conclusions

This paper describes how agents can be used to support price negotiation in a NVoD service. The supposed reference scenario is limited to the case of a single service provider and it is applicable only when the provider can lower the price as the number of customers grows. Under these assumptions, the service provider may accept to lower the price for a showing to increase the number of customers. This requires a price negotiation that may need to be iterated several times to agree on a satisfactory price both for the service provider and the customers. Agents can help dealing with this situation because they can perform the negotiation without directly involving the customers. Customers simply tell their personal agents the desired parameters and let them autonomously find an agreement with the service-provider agent. The presented work can be extended in two ways: supporting the case of many service providers and allowing agents to negotiate also the quality-of-service for the showings.

5. Acknowledgement

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6. References

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