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Increasing the popularity of cloud computing by improving its market performance

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Autonomically adjustable cloud markets enable fast, simple and inexpensive ways to sell and purchase electronic services.

Cloud computing is a novel paradigm that offers access to resources (e.g., software services, platforms and hardware infrastructures) on demand without regard to where the services are hosted or how they are delivered, much like traditional utilities such as water, electricity, gas and telephony.[1] Although cloud computing is in a period of strong growth, its technology is still in its infancy.[2] Large organizations are often unsure whether they have sufficient maturity to manage the complexity of the processes (e.g., additional outsourcing and contracts) that cloud computing entails. The highly heterogeneous cloud market makes it difficult to know how (and where) to find, purchase and use appropriate services.

Despite substantial effort to develop them, efficient market models for virtual goods are lacking, as are methods for defining and managing such goods. Due to the broad variability of resources and the still low number of market participants, the paucity of standardized virtual goods can lessen the chances of selling or purchasing a service, i.e., market liquidity is reduced. Successfully addressing these issues could determine whether (or when) cloud computing will finally make traditional vendor relationships obsolete.[3]

However, even with standardized goods, currently static electronic markets cannot react to dynamic (i.e., unexpected) changes in user requirements for services. This results in poor market performance and drives away potential market participants. To counteract this problem, static cloud markets must be replaced by marketplaces able to modify their properties in response to current market trends. A well-formed cloud market should adapt to the needs of its participants as well as address the impacts these requirements have on the market itself, which is only possible if the market has self-monitoring and self-adaptation capabilities.

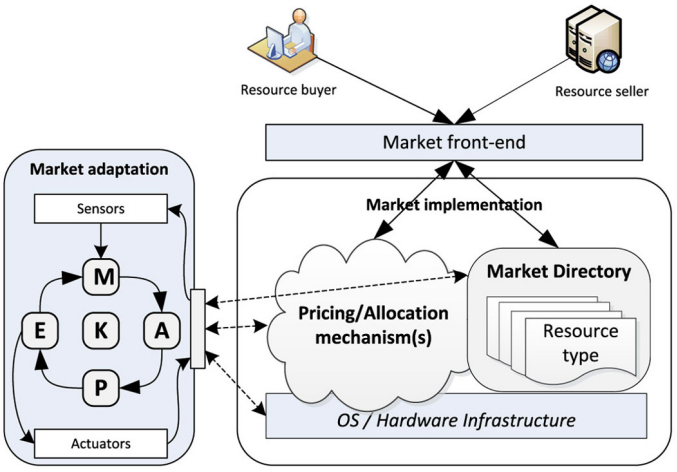

Figure 1. *Proposed architecture of autonomic cloud markets. The trading mechanisms and market directory are accessed through a distributed front-end. Monitoring sensors retrieve performance information from the market mechanisms and underlying hardware infrastructure. The adaptation cycle uses the knowledge component to derive actions that modify market properties in terms of economical and infrastructural behaviour. M: Monitoring. A: Analysis. P: Planning. E: Execution. K: Knowledge. OS: Operating system.*

In the context of the FoSII (Foundations of Self-Governing ICT Infrastructures) project[4] at the Vienna University of Technology, we are investigating autonomic self-aware markets that can change, adapt and even redesign their anatomy and/or underpinning infrastructure during runtime to improve their performance (see Figure 1). In our idea of cloud markets, user requirements are channeled through a relatively small number of product groups managed by the publicly available market directory.[5] This approach is the basis for a new framework for standardizing goods (which is different from de facto standardization and de jure standards). It allows coordination between traders, who realize mutual gains. Furthermore,

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compared with non-standardized, 'traditional' methods of comparing each buyer's request with each seller's offer, our approach facilitates the search for trading partners, increases market liquidity and possibly improves social welfare (i.e., the gain of sellers and buyers) because of the possibility of creating specialized product niches.

To enable trading between a seller and buyer, their requirements must be understood by both sides. This is only possible if their requirements are specified exactly the same way in their respective structures. Consequently, we use XML documents called SLA (service level agreement) mappings to map the differences between two service specifications.[5] This solution enables users to keep their old templates, which may already be used in other processes, while trading in the new environment.

However, the SLA mapping approach raises many questions. For example, how many and exactly which groups of products should be placed on the market to maximize market liquidity? How should market performance be measured to assess current market liquidity and recognize when change is needed in market properties? Finally, what adjustments to existing product specifications are required to react to dynamic changes in user requirements?

We have introduced a so-called market adaptation component to autonomically measure and analyse market performance, as well as to derive and execute self-modification actions to achieve a set of predefined market goals (e.g., increasing traders' utility or benefit).[6,7] The adaptation takes the form of an 'MAPE-K' process comprising five components: a monitoring component, which uses monitoring sensors to observe the performance of market goals; an analysis component, which analyses monitoring data to derive possible actions for market adaptation; a planning component, which plans the execution steps of the action set; an execution component, which executes the actions; and a knowledge component, which stores analysed monitoring data and experiences from previous adaptations.

In the context of the Austrian national FoSII project, we have so far implemented an initial middleware prototype for autonomic management of service specifications that allows users to define, manage and apply their SLA mappings. Moreover, we have developed and implemented a monitoring methodology for measuring performance of cloud markets in terms of both economical and infrastructural behaviour. Currently, autonomic market adaptation is limited to modifying service specifications and product groups with respect to current market performance and user requirements. Our first set of results shows a significant increase in market liquidity and traders' utility compared with existing cloud markets.

However, these findings are only preliminary. The potential of autonomic self-aware cloud markets has yet to be fully exploited. For example, besides modifying services offered on the market, actions may include scaling market infrastructure up or down, modifying market participants and even adjusting market 'rules' to change the market mechanism or its properties. These capabilities will further increase the welfare of market participants and reduce market operating costs. The expected result will be a well-formed market that is attractive to many traders and increases the popularity of cloud computing in general.

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