Comments on "In-Memory Databases in Business Information Systems"

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1 Introduction

In-memory databases, which keep the full data set in the main memory for reading accesses, and their application in business information systems, receive more and more attention due to the development and marketing of SAP technology HANA. In issue 6/2011 of the journal Business & Information Systems Engineering, a total of 11 authors discuss potential applications of in-memory databases in business scenarios in 6 articles (Loos et al. 2011). Thereby, questions about the capability of in-memory technology, resulting consequences for OLTP and OLAP applications as well as implications on the architecture of business information systems, amongst others, were in the focus of the discussion. After publication, the first author received feedback and suggestions. Three of these responses resulted in written statements:

- Strohmeier focuses on the question whether or not future OLTP and OLAP applications should be integrated. He states that concepts for both an operative decision support and for the provision of operative real-time information need to be developed. As a result, he sees a demand for more research in the area "Operational Business Intelligence".
- Piller provides more examples of application scenarios, which emerge with in-memory databases. For instance, operative reporting, adaptive planning, explorative mass data analysis or the analysis of consumer data from embedded systems.
- Schütte explains, after a description of implicit presumptions and requirements for in-memory technology, the potential of in-memory technology using a practical example of the EDEKA group, which he sees in batch processes, initial supply, and release change.

If you like to comment on this topic or another article of the journal Business & Information Systems Engineering, please send your feedback to loos@iwi.uni-sb.de.

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2 Main Memory Databases for Corporate Information Supply – Technical Innovation and Functional Stagnation?

The consolidation of analytical and operational functionalities (e.g., Plattner 2009) is often called the show-piece of a positive corporate consequence of main memory database system as these functionalities have been provided by two separate system categories for about two decades, due to the limited capacities of operational systems. Such a consolidation appears to be technically useful, as extensive and complicated architectures may be considerably simplified (Winter 2011). Furthermore, a consolidation seems to be functionally useful as well, in order to improve the reaction times of the users by reducing data and analysis latencies (Hackathorn 2003) while replacing the media disruptions occurring in processes of operational and analytical activities.

The intensive technical discussion about the potential of main memory databases, still necessary in the moment, neglects functionally central and critical aspects. It has been stressed that the integration of data relevant for analysis from heterogeneous system environments is a prominent function of current analytic information systems which cannot be replaced simply by integrated (operational and analytic) application systems (Winter 2011).

However, the bad fit of operational information and decision needs with the current offer of tactical (and in favourable cases strategic (e.g., Eckerson 2007; White 2006)) analytical features is mostly neglected. Both OLAP and even more data mining analyses show a clear tactical character as they aim to satisfy complex information needs which require a certain time to be performed and also require methodology and business knowledge. The time needed is composed of the time to (eventually repeatedly) specify the analytical request and the interpretation of the results. This user determined analytical latency cannot be reduced by main memory database systems.

This leads to the question of how often such complex information needs occur in the context of transactional systems while processing operational tasks. Obviously, OLAP analyses can also cover simple, ad hoc or regularly arising information needs like "current sales volume of a specific client" or "downtime of a specific machine". However the application of OLAP appears to be unnecessary and oversized, as current operational information systems regularly offer adequate query and reporting features in these cases. Furthermore, it is questionable if the time needed to specify, (repeatedly) perform and interpret complex analyses is even available in the operational context. Furthermore, it is questionable if the time needed to specify, (repeatedly) perform and interpret complex analyses is even available in the operational context. Quite often information needs have to be satisfied in a very short time due to operational job organization (e.g., service center organization with direct customer contact) as well as operational efficiency. Finally, it cannot be assumed that operational endusers have the required qualifications to specify, perform and interpret such complex analyses. In conclusion, the consolidation of operational functionalities and tactical and strategic analytical functionalities based on main memory databases appears to be technically possible (e.g., Kemper and Neumann 2011), but only restrictedly useful in a functional way.

In order to actually exploit the existing potential, the technical innovation needs to be conducted by corresponding functional innovations in the area of operational decision support. This again begs the question of possibilities and limitations of "Operational Business Intelligence" (e.g., Glukowski et al. 2009; Eckerson 2007; White 2006). Despite certain discussions in practice and first research publications this issue is hardly being dealt with at the moment, neither from a conceptual nor from a methodical point of view. Recurring topics of the discussion are the integration of decision support into operational business processes (e.g., Bucher et al. 2009) and thus into corresponding operational systems (e.g., Nijkamp and Oberhofer 2009), the provision of operational real time or near time information (e.g., Azvine et al. 2006), and especially the clear domain and function specific focus to support concrete operational decision problems (e.g., Eckerson 2007). The main challenge for research on "Operational Business Intelligence" is the combined realization of these topics, a field which in my opinion has to be distinctly intensified. The large number and heterogeneity of the individual problems which have to be dealt with in business functions and the necessity of a broader inclusion of research fields such as business process management (with specific subareas like Process Performance Management or Business Activity Monitoring) and Operation Research enlighten the extent and the demands of this upcoming challenge. The future functional development will ultimately decide on the manner and the extent of improvements of information supply based on main memory databases – simply providing "Real-time-OLAP", although a step forward, will not exploit the potential of main memory databases.

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3 Comments on "In-Memory Databases in Business Information Systems"

In issue 6/11 Peter Loos and other authors discuss the question to what extent in-memory computing, as a basic data management technology, can sustainably influence the conception and development of business information systems (Loos et al. 2011).The authors emphasize the potential of in-memory technology, describe its evolution and sketch the status quo. As typical characteristics of in-memory database systems they point in particular at high performance gains when analyzing huge data volumes, a flexible and very fast access to all company data as well as the unified processing of transactional and analytic information.

Far-reaching consequences are expected for business information systems. For example, Lechtenbörger and Vossen assume a considerable effect on the evolution of standard business software. Lehner anticipates that business applications will be designed with focus on underlying data flows and will work on a need-to-know principle. A revolution leading to completely new designs for modern information systems is expected by Kossmann. In the opinion of Fabian and Günther there are good arguments that in-memory technology can lead to a new level of quality for in-depth business intelligence – a view which Zeier et al. expect for nearly all components of business software. Winter finally imagines the possibility of wide-ranging consequences for the architecture and processes of the entire business information logistics.

Besides mentioning example use cases for in-memory technology, several authors in Loos et al. (2011) emphasize the need to closely combine the new technical possibilities with application knowledge and modern business requirements. Only then the expected potentials of in-memory computing can fully be realized. In the following this aspect is taken up again – in particular to stimulate further discussions and contributions.

The use of in-memory data management in business applications is still a relatively new field. A comprehensive assessment is therefore not yet possible. First studies use explorative methods to present trends and introduce new ideas. In Piller and Hagedorn (2011) business processes and application types are characterized with respect to the capabilities and potentials of in-memory technology. The results were used to describe typical application patterns where in-memory databases could provide additional benefits. Examples are:

- The pattern "Operational Reporting" describes the processing of large volumes of transactional data for fast and well informed decision making in day-to-day business activities. The immediate availability of analysis results with most current information allows the usage of transactional data beyond traditional areas – in particular to directly control operational activities. Typical examples are quality monitoring for wafer fabrication in the semiconductor industry or the analysis of point-of-sales data in retail.
- In the application pattern "Adaptive Planning" huge performance gains allow to obtain results from planning runs on the basis of most current data. Furthermore it is possible to immediately react on changes with new calculations. Due to a significantly reduced latency, results from planning can be adjusted much better to momentary circumstances. Inaccurate results with partly outdated information through batch processing will thus be avoided.
- The "Explorative Analysis of Mass Data" describes investigations of large data volumes with a free choice of selectable analysis criteria. Almost classical examples are the analyses of contribution margins and customer segmentations. Short response times and the possibility to use flexibly chosen combinations of characteristic values enable highly interactive and ad-hoc investigations – far beyond today's possibilities which often use batch processing and pre-defined data aggregation.
- For providers of traditional business software in-memory technology seems to open up a new domain. It enables the processing of extreme volumes of

highly dynamic consumer data from embedded systems, as they appear, for example, in domestic homes. The corresponding analysis results can be leveraged in consumer apps as well as in applications for business purposes.

Emrich et al. discuss additional possibilities for a comprehensive integration of analyses and simulations with operative, tactical and strategic processes and decisions (Emrich et al. 2012). With in-memory technology one could, for instance, explore consequences from changes in business models and processes in real-time. High performance investigations using semantic context models could enable, e.g., a context sensitive support of business processes, the proactive identification of optimization potentials or "on-the-fly-adaptations" of processes.

In industries with traditionally high volumes of data the use of in-memory computing seems to be particularly promising. With significant improvements in calculation performance, functional requirements for the processing of huge data volumes could be realized for the first time and already existing analytical methods would finally be accepted by end users and applied during daily business. For examples in retail see (Schütte 2012; Piller and Hagedorn 2012).

The examples discussed above show that in-memory technology can have a massive impact on the redesign of existing information systems and the preferred way of their use within business processes. Explorative investigations are necessary which systematically identify and validate new potentials of this technology for business software. A qualification of business processes and domains with respect to characteristics, describing an ideal dataflow and its processing, is a possible starting point. In areas where the use of in-memory data management seems promising, potential benefits of this new technology need to be carefully assessed. A largely business driven approach is also feasible. Winter, for instance, suggests in Loos et al. (2011) a specification of reference models which systematically exploit the full potential of growing, heterogeneous and comprehensive data assets. Design-oriented business and information systems engineering research offers a multitude of methods to support the identification and development of innovative IT solutions.

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4 In-Memory Technologies: Considerations on Justification and Application in Large Systems

4.1 Introduction

In-memory technologies that strive to store all data directly in main memory have been discussed in BISE 6/2011 from various perspectives. In the debate on in-memory technologies two aspects are especially prominent. Firstly, argumentation for the application of in-memory technologies is quite diverse and attached to requirements. Secondly, there is an important reason for the application of in-memory technologies from the perspective of managing large systems which has hardly been mentioned to date.

4.2 In-Memory Argumentation and Its Implicit Assumptions

In literature, various arguments are found for the application of in-memory technologies. The following points are of main importance:

- Integration argument: Integration, meaning the unification of OLAP, OLTP- and BI-systems, is presented as a core argument for in-memory technologies (Lechtenbörger and Vossen 2011; Winter 2011; Zeier et al. 2011).
- Storage argument: The abandonment of redundant modeling and storage of aggregated data as well as the possibility to efficiently apply column-oriented database systems offer advantages (Fabian and Günther 2011).
- Technical simplification argument: In the technical efforts to reduce complexity – e.g., tuning of databases or storage hierarchy (Kossmann 2011) – in-memory technologies are considered advantageous.
- Decision orientation argument: An additional important argument is the extension of decision techniques made possible in real-time by in-memory technologies (cf. Fabian and Günther 2011; Loos 2011).

The arguments given implicate some presuppositions a few of which are shown in the following.

Possible realization: The application of in-memory technology can only be considered when the speed of growth of data volume requirements is lower than the increase of the storage capacities in the main memory, as long as sufficient capacities for the planned solution are provided at the start of the system's implementation.

Speed or efficiency relevance: The application of in-memory technologies presumes first of all a general necessity for main memory oriented data storage. This is given only when a required application cannot be provided with the help of available concepts for the necessary response time behavior. In an alternative model, an in-memory oriented solution could be developed and applied more efficiently. In this case, criteria would have to be designed as to when the singular application of an in-memory approach would be superior to a traditional one.

IS-architecture conformity: The application of in-memory technologies leads to different IS-architectural ideas which have not been discussed so far. In the past, various decomposition criteria were used to differentiate a system into subsystems, which on a technical level were supposed to allow for various release levels. Contrary to monolithic considerations, e.g., of an old SAP R/2 or even R/3 system, today complex application scenarios with different release levels are in use. In such application architectures it is not advantageous to install a new technique for a partial problem if this is not strategically needed for experimental reasons.

Furthermore, it is state of the art that a middleware acts as an essential communication layer for executing complex system-transcending processes. The application of an in-memory database solution would therefore require the use of system-transcending processes on a technical level in the main memory; otherwise the expected process velocity advantages will not occur. Without the vision of a future IS-architecture only partial problems can be dealt with using in-memory approaches. Integrated business software systems cannot be applied economically without a superior architecture. Possibly in-memory technologies will assist a return to monolithic systems where the advantages of such a technology are especially evident. It is important to start a theoretical discussion on alternative conceptions of architecture, as the author assumes that all standard software providers will continue spreading in-memory approaches extensively. Here business and information systems engineering and computer science should actively take part in the discussion of architectural conceptions. For the providers of standard software the question arises how future IS-architecture will be designed if almost all requirements to a system are to be supported by in-memory database technologies.

4.3 In-Memory Approaches from a Practical Technical Perspective

The use of application systems and systems on lower layers in practice still poses far-reaching problems in large systems. These specific technical limitations have not been discussed in in-memory technologies so far, even though they have an enormous potential for difficulties and danger for the system itself and for business operations. The author suggests a debate on these fields, as it would open a new perspective to the approach, fitting into thoughts on the technical simplification of processes (Kossmann 2011). It is of course not so much the simplification that argues for an application, but the necessity to reduce dependencies on the runtime of technical systems when changes in the processes occur.

To show this, examples shall be elaborated from the use of some 350 SAP-systems of the retail corporation EDEKA which might be solved by in-memory approaches. The systems have been designed as template modules and are placed in template surroundings, differentiated by development, test, and production systems. The Lunar application system constitutes a complete systems model for all trade levels, development levels, and program areas. The diversity of systems common in today's network application scenarios creates an enormous challenge, e.g., when changing releases. Lunar GmbH is the software provider for the EDEKA group that develops the software in release cycles and installs them in the EDEKA units in fixed intervals, after tests at Lunar and at the relevant units have been made. Requirements regarding design and further development of products and product families are therefore comparable to the tasks of a standard software provider.

For the EDEKA-Group, available windows for applying release changes in their units are becoming rather narrow, as they use quite a number of proprietary products for standard releases with at least annual changes in many units. It is a considerable task for the units to find the necessary time slots for release changes as they do not become less challenging with increasing data volumes. A significant improvement of the situation could be expected with a successful support of in-memory technologies on technical layers and not only on application layers. Due to the runtime needed for larger release changes, merely one prolonged weekend per year remains available; this creates an enormous economic risk.

Batch processes pose a further problem when working with centralized databases and high data volumes. To perform the large number of batch processes in a company at a given time is quite difficult, such as the booking of goods arrivals, sales and invoices of the day, automatic disposition runs, etc. In view of the situation that opening hours in retail trade are continuously extended, operation times of 7×24 hours are relevant challenges for central IS architectures. Here in-memory approaches could render relief with the operation of systems not in discussion so far.

Another example from practice is the high change rate in mass data occurring daily in trade operations, either as initial supply for new data structures or as change support for a large number of stores. These challenges of a more technical nature could also show enormous performance improvements with the help of in-memory technologies (Sigg 2011).

4.4 Outlook

In-memory technologies promise real-time applications and thus something like the "Perfect Processor" in a realistic and not only logical form, as propagated by McMenamin and Palmer for systems analysis. Today, however, a different problem has emerged: The perfect processor on a technological level lacks the perfect logical model, and this means enormous conceptual challenges for business and information systems engineering against the background of technical capabilities.

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