App Design For Use - A Manager Perspective for In-Memory Technology*

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* The state of the art was examined in a joint research with an in-parallel research project already published in [1].

Abstract—Information systems (IS) intended to help managers are known as management support systems (MSS). The present situation is favorable for a redesign that applies in-memory apps. Such apps promise to support managers with benefits ranging from reducing time for MSS data entry and analysis to new topics of analysis. Based on findings from a literature review and results from a workshop with an expert focus group validated with one-on-one manager interviews, we propose six guidelines for an app design that contributes to greater MSS acceptance: (1) A tile design for the entry-page. (2) A manager news ticker as starting point for self-service analysis. (3) An intuitive navigation known and appreciated from consumer IS. (4) A collaboration tool to foster joint managerial problem solving. (5) Exception reporting which includes personal exception limits and a push function. (6) In-memory apps should be evaluated by their capability to perform new types of analysis.

Keywords—Information Systems (IS), Analysis and Design, Human Factor in IS Design, New-Generation Managers, Management Support Systems (MSS), In-Memory Technology, App Design, Self-service IS, mobile MSS

I. INTRODUCTION

Information systems (IS) intended to help managers are known as management support systems (MSS). They have a five-decade tradition [2-6] and cover management information systems (MIS), decision support systems (DSS), executive information systems (EIS) and more recently, knowledge management systems (KMS), as well as business intelligence (BI) systems for managers [7].

Leveraging the declining cost of random access memory (RAM) and the increasing capabilities of multi-core central processing units (CPUs), in-memory technology apps (hereafter referred simply to as in-memory apps) are currently being discussed heatedly and promise to contribute to a better MSS design [8, 9]. Such apps are small encapsulated software programs applying in-memory technology [10]. They provide answers in milliseconds [11] or at least there is no substantial delay between the occurrence of an event and the use of the data [12].

In-memory apps are field-tested and ready-to-use [9], but from a manager's perspective, they lack impact [13]. Covering the following two developments, we propose an MSS redesign that leverages the benefits of in-memory apps. [1]. Firstly, digital natives are increasingly present in organizational management, along with digital immigrants who have learned to engage with IS as adults and have developed into MSS users over the years [14, 15]. Secondly, due to technical progress including a new palette of MSS functionalities, such as collaboration, context-sensitive exception reporting or “do more” functions [16], managers should be able to operate MSS more effectively themselves—even when they are mobile [6].

Furthermore, beyond pure IS deployment (plan, build, run”), a new IS design must broaden its scope to include managers' IS use and impact perspectives [17]. However, such an “IS design for use” has barely been covered for apps up to the present [18]. In particular, it is unclear how in-memory technology can accommodate managers' new willingness to undertake MSS self service [19].

Given these considerations, the objective of this article is to propose guidelines for an in-memory app design that contributes to greater MSS acceptance from a manager perspective. We cover both consumer managers (those who primarily consume IS information) and analyst managers (those who primarily work more interactively with information from IS). In addition to [20] artefacts of models, methods, instantiations, and constructs, the proposed guidelines contribute to theories specifying how IS should be designed based on kernel theories [21]. We answer two research questions:

- What are new-generation managers' requirements for self-service in-memory apps?
- Accommodating these requirements, what constitute suitable guidelines for ensuring an appropriate app design?

We follow the emerging tenets of design science research (DSR) in human-computer interaction (HCI, see [22-25]). We motivate this article in terms of current gaps in MSS design and suggest in-memory apps to close the gaps. Based on findings from a literature review, we formulate our design guidelines. Following [26, 27] ideas on mixed method research, we vali-

date our arguments in a workshop with an expert focus group, and then enhance the proposed design guidelines with experience from practice that we gathered in one-on-one manager interviews. The article concludes with a summary and avenues of future research.

II. STATE OF THE ART

A. Search Strategy

We started our literature review with a journal search focused on IS research outlets provided by the London School of Economics [28] and complemented them with journals from HCI [29], computer science, system and software engineering and added proceedings from ICIS, ECIS, AMCIS, and HICSS. We used EBSCOHost, ScienceDirect, Google Scholar, and AIS Electronic Library to access the journals. Our Boolean search string combined real-time or in-memory with MSS (design). We then examined the titles and abstracts of promising publications. Due to only 18 hits in total (including just two high-ranked articles, we complemented our search on tier-2 IS journals and proceedings, and readjusted MSS design with IS design in general (Table I). After a final back and forward search, we found 100 articles to be relevant (Figure 1, see also [1]).

TABLE I. BOOLEAN SEARCH STRING

AND	OR	OR					
		Real-time	Decision support	Management	Dashboard	User	Acceptance
		In-memory	Enterprise resource planning (ERP)	Data warehouse (DWH)	Application / app	Mobile	Self service
		IS design	Management support systems (MSS)	Management information systems (MIS)	Executive information systems (EIS)	Decision support systems (DSS)	Knowledge management (KM)

B. Literature systematization

We structured the 100 publications classified as relevant in terms of elements of IS design theories and the research approach they applied (Figure 1, [1]).

(1) *Elements of IS design theories*: Focusing on IS design, cognitive fit states that decision making is efficient and effective when a problem is presented in line with an individual's approach to problem-solving [30]. The theory of task-technology fit (TTF, [31]) is a user-evaluation construct for IS success which describes the degree to which IS accommodates users' tasks. TTF aids what factors should be included in an IS model, however, does not provide direct advice on the design of (innovative) artefacts [32] and does not consider that a one-size-fits-all MSS design for a "typical" manager is no longer sufficient [17]. In contrast, a design that would meet individual IS use characteristics of all potential managers is untenable from an efficiency perspective. By segmenting different classes of user-group preferences, IS design for use provides a way to achieve a balance [33]. Hence, we assign our literature research to the TTF theory and take MSS design for use as our case example closing the TTF gap by providing concrete design guidelines. According to [34], IS design theories consist of three elements (Figure 1):

- Leveraging findings from HCI research [35], our systematization starts with a user model. An IS user-group analysis segments user groups and their characteristics that influence how managers use IS [36]. The effects of use occurring to managers while using IS complement our IS design for use proposal [37].
- User requirements cover both a functional and a non-functional perspective [38, 39]. The first addresses "what" in-memory technology is supposed to do or must do (purpose). The latter reflects "how well" MSS perform their function within their environment [40].
- Design guidelines, in turn, go beyond mere requirements to serve as predefined actions specifying how in-memory apps in MSS are brought to life [41]. They contribute to both models, concrete systems for IS design like specific in-memory technology features [42], and methods, which describe the process of, for example, real-time decision support [43].

Fig. 1. Findings of the Literature Review

(2) *Research approach*: The research approach influences the granularity of requirements and design principles from high-level findings:

- Publications with a behavioral focus rely on observations and apply empirical methods [44]. We differentiate between experiments, findings from literature reviews regarding behavioral topics, and surveys [45, 46]. Case studies are another way of conducting behavioral research [47].
- Design science approaches give recommendations for the conceptual design and implementation to create a better world [34]. We divide these publications into single items and list approaches investigating specific aspects and frameworks merging requirements with technology aspects.

C. Gap analysis

(1a) A user perspective on in-memory technology exposing different MSS situations is missing: With 28 publications researched (Figure 1, first column), we evaluate the state of the art of IS user models as comprehensive. Seven publications provide methods to differentiate individual cognitive styles and cover techniques for user-group analysis [15, 48]. In turn, 21 publications cover effects of IS use (including MSS) on human beings. These studies examine characteristics that have an impact on IS (e.g., women vs. men; [49]) or identify manager

user-group characteristics and their MSS usage [50]. In a current study of managers [51] two basic working styles among managers and their different MSS usage are stated: Analyst managers seek causal relationships, prefer quantitative data, and pay attention to details [48]. Consumer managers, in turn, pay less attention to detail and rely most often on content in a predefined order [36]. We consider this approach as appropriate for our research model because it offers a distinction of different user types—a prerequisite to examine managers’ IS acceptance more in detail than the state of the art does [51].

More in detail, [52] consider real-time decision support to be one of the current issues for MSS design. However, in-memory databases in companies [53] and dashboards for real-time BI [54] lack a business perspective in content and handling especially when supporting analytical applications [55]. Furthermore, the examined publications most often follow the black-box model and focus on layouts for desktop PCs [56, 57]. However, the publications either provide just lists of software components without a rigorous basis for their selection [58, 59] or examine attributes of single software components only [60]. Just two articles consider managers’ MSS use situations [61, 36], but stayed on a generic level [62].

(1b) User requirements lack a focus on corporate management: 36 out of 100 publications deal with requirements for in-memory technology (Figure 1, second column). Herein, 26 publications focus on non-functional requirements [10, 62-65]. In turn, just 10 out of 100 publications cover functional requirements for in-memory technology [19, 65-68]. We found no publications that support corporate management. Especially, new functional types of analysis for real-time corporate management are missing [53]. Focusing on managers’ non-functional perspective on in-memory technology, a more user-driven apps design would contribute significantly to a better MSS perceived usefulness.

(1c) Design guidelines for in-memory apps lack impact for practice: We examined 20 publications about IS models outlining guidelines for in-memory technology in general (Figure 1, third column). However, these references focus on technical details such as cloud computing [69] or dashboard implementation [70] and other [71, 72]. [62] provide a matrix consisting of four use cases for operational analytics and the BI/DWH environment as well as [68] which lays out six patterns of in-memory technology. However, both publications stay generic and thus concrete design guidelines applying in-memory technology are missing.

Focusing on methods for IS design, we researched 16 publications. They cover the influence of in-memory technology on data warehouses [73] and on the implementation of real-time dashboards [74]. Another three articles address in-memory technology and mobile analytics [67, 75-77]. Accordingly, [78] classify three mobile use contexts, but none looks at managers’ mobile information access. Our review shows that a more user related perspective on methods is needed. Hence, we expand our research topic towards in-memory apps for managers—supporting them when they are mobile [77].

(2a, 2b) Concrete interaction with practice when designing MSS is missing: With 56 publications our literature review reveals a slight preference for behavioral approaches (Figure 1,

fourth column). Focusing on case studies (25 references), research justifies the general adoption of in-memory technology, but mostly omits individual managers’ benefits. The 44 publications adhering to design science research in IS we researched, apply frameworks (18 references) and single item/list approaches (26 references, Figure 1, fifth column). Frameworks are offered for BI and OLAP/OLTP topics [76, 79, 80]. List approaches give summaries of in-memory capabilities [68] and consider suitable data for analytics [81]. However, an interaction with practice is missing.

Thus, (non-functional) design guidelines for in-memory apps to be incorporated into MSS for new-generation managers’ self service are missing. We apply our findings from the literature review to propose such guidelines and their associated specifications, evaluate our arguments with results from a workshop with an expert focus group, and demonstrate utility of our results in one-on-one interviews.

III. DEVELOPING DESIGN GUIDELINES

A. Principle of economic efficiency

To structure design guidelines we propose Poppers’ [82] deductive method and apply the principle of economic efficiency. It is a paradigm in business research addressing the ratio between benefit and cost [83]. Providing a surrogate, we apply the “black-box method” [84] and differentiate between the basic criteria of solutions capabilities (IS output) and resource requirements (IS input). The first refers to the benefits of in-memory apps to support managerial decision-making. The latter covers the input needed for generating the output.

Solutions capabilities (IS output): Referring to the IS success model [85, 86], IS output can be specified with different information and IS characteristics relevant to users. We start with the (user) interface design in general [57] and propose two design criteria: (A) information presentation and (B) IS dialog control. The first describes the basic screen design and “look & feel” of the proposed app output [87, 88]. The latter refers to the way of accessing the app from a managers’ user perspective [57]. We go on with (C) functions that should be provided by in-memory apps. (D) Information management covers the MSS flexibility to accommodate working styles [15] and bears in mind the growing importance of manager self-service IS [94]. Resource requirements (IS input): Resources required to generate the output described before are specified in terms of (E) effort differentiated by “cost and time” of IS design [89].

B. Design guidelines

1) Information presentation

Managers want the most important information at a glance (DG 1). [97] identify a consistent information overview on the first screen as an important factor of managers’ perceived usefulness. Referring to managers’ lack of time, [36] proposes most important news with a “read more” function (DG 1a). [59] state, that managers usually work with few key performance indicators (KPIs) and “modern” IS design has to display them in a clear and eye-catching visualization (DG 1b). Finally, based on former research [98, 14, 53] we suggest collaboration tools right from the beginning (DG 1c).

In-memory apps should offer graphs and portfolios instead of tables and numbers (DG 2). Tables and numbers are harder to read especially on mobile devices, thus managers prefer graphs and portfolios for information presentation [36]. Following [59], managers prefer bar charts (DG 2a, followed by line graphs (DG 2b) and more complex chart types (DG 2c) such as waterfall diagrams.

2) IS dialog control

The smaller the devices, the fewer analysis steps users accept (DG 3). [99] found that managers, especially when they are mobile, use IS most for notification and communication, thus they are not willing to perform numerous clicks to receive information [36]. Bearing in mind that by 2015 37% of managers will use mobile IS [100], interactive graphics are highly relevant (DG 3a). To better utilize the reduced and valuable screen space on mobile devices [101], mobile IS should offer detailed information only when managers use the “read more” function (DG 3b, [75]). Bookmarks, in turn, are a way to reduce the analysis steps by saving time for navigation to important and frequently used views (DG3c, [102]).

Analyst managers prefer a more interactive navigation style, whereas consumer managers like a predefined flow of charts with a few deep-dive options (DG 4). Following our differentiation between analyst and consumer managers, more tech-savvy analyst managers ask for breadcrumbs, filters, drills, sorting, etc. (DG 4a, [103]). Consumer managers, in turn, need a more intuitive dialog control, which can be characterized by a more static, predefined page-by-page mode (DG 4b, [50]).

TABLE II. STRUCTURING DESIGN GUIDELINES FOR IN-MEMORY APPS

	Design criteria		Description (references)
IS output	(User) interface design	(A) Information presentation	How is the first basic screen in general and is the design consistent [87,88]
		(B) IS dialog control	How intuitive is the user guidance and are the menus reasoned [90]? Are all drill, filtering, sorting functionalities supported [91]?
	(C) Functions		Is it possible to define exceptions and to visualize them [92]? Is it possible to leave comments to support collaboration across the company [93]?
	(D) Information management		How flexible are IS for adapting to different use situations (manager working style, MSS use cases, and access modes [94, 36]? Are there capabilities, especially a programming language, to incorporate add-ons [95]? How is managers' self service considered in IS design [94]?
IS input	(E) Effort		How much money should be spent for implementation [89]? How much time for data analysis could be saved [96]? Which new types of analysis are possible [10]? What are the most frequently used data [81]?

3) Functions

In-memory apps should have an integrated exception reporting implemented (DG 5). When performance undercuts a threshold, managers often have to react immediately [99]. These exceptions should be automatically exposed by a push function (DG 5b). Furthermore, there must be a way to define personal exception limits and visualize them on dashboards (DG 5a, [92]).

In-memory apps should implement more collaboration tools (DG 6). Based on [14], there is a growing demand for

collaboration tools. These should support collaborative activities, such as adding comments on charts or single KPIs to start a discussion (DG 6a, [102]), and a repository to track and store all comments in a dialog center (DG 6b).

4) Information management

In-memory apps for managers need to be flexible in several dimensions (DG 7). As there is a growing range of different MSS use situation [36], there is a need to adapt the graphical user interface (GUI) by customizing functions (DG 7a). From a more technical perspective, a programming language for add-ons should be available (DG 7b; [95]).

Managers increasingly rely on IS self-service access (DG 8). Through the expanding number of new-generation managers, self-service access is of growing relevance [13]. Supporting their IS use, apps must handle changing information presentation formats or navigation elements (DG 8a, [67]). Following [104], future managers will ask for a more accurate forecasting (DG 8b [105]), scenario techniques, and simulations (DG 8c [106]).

5) Effort

The OLAP/OLTP merger is a technical revolution (DG 9). The merger to so-called OLXP [65] allows performing instant and flexible analysis directly on transactional data [107]. The benefits can be measured by established metrics such as cost savings (DH 9a [108]) or by timesavings for data analysis (DG 9b [109]). Furthermore, new types of analysis are possible (DG 9c [68, 110]). [81] assess the frequency of access (DG 9d) to often-used data as a way to measure user acceptance, because a slow access tax the manager's patience.

IV. VALIDATION

A. Workshop with expert focus group

Validating our design guidelines, we performed a workshop with an expert focus group consisting of twenty-five participants. They belong to a working group of executives (L1) and managers (L2) of the competence center corporate management systems at University of St. Gallen and meet three times a year since 2006 to examine trends in managers' IS support. They represent a fairly balanced sample among executives and professionals from business department and IT/BI sector. An expert focus group provides the benefits that researchers see the practical relevance of their topic and profit by collaboration with practitioners in a personal atmosphere [111].

A pre-test of the questionnaires was performed with three persons to ensure the relevance, completeness, and distinctiveness of the questions as well as an appropriate length. Data was then obtained in a *two-hour moderated workshop* in June 2013. The workshop started with an introduction by two moderators. Given that not all focus group members were familiar with in-memory technology per se, its benefits, and use cases, the moderators showed two case examples. The first example was an app about material planning allowing personalizing the entry page by displaying different KPIs and the second covered a planning process within a range of worst case, most probable case and best-case scenarios.

B. Results

Afterwards, the managers had to vote on two different layers (see table III). Firstly, they were asked to indicate their approval to the nine *design guidelines* (DG1-9, column 1). Secondly, *associated characteristics* (DG1a-9d, column 7) of the guidelines provided deeper insights. All questions were answered on a five-point Likert scale: 1) not important, 2) less important, 3) undecided, 4) important and 5) very important. Means (μ) and standard deviations (σ) were calculated for all responses. Because of small sample size, data were analyzed with Mann-Whitney U tests to identify significant differences in working styles (analyst vs. consumer managers) and Wilcoxon signed-rank tests to focus on remarkable results significantly greater than four. We discuss results with significant p-values < 0.1 and mark them with a star scheme ($p < 0.1 = *$; $p < 0.05 = **$; $p < 0.01 = ***$).

1) Information presentation

Both, analyst ($\mu_a=4.73$) and consumer managers ($\mu_c=4.89$) significantly prefer a start-up screen with all relevant information at the top ($p_a=p_c<0.01$; DG 1). In detail, both ($\mu_a=4.21$ to $\mu_c=4.55$) want a news feed with a “read more” function on start screen (DG 1a), especially consumer managers ($p_c<0.05$). The reduced amount of KPIs displayed in a clear visualization (DG 1b) is a highly significantly important ($p_a<0.05$ to $p_c<0.01$) associated characteristic for both ($\mu_a=4.57$ to $\mu_c=4.64$).

Managers agree to our guideline that apps should offer graphs instead of tables (DG 2). Our proposal has means of 4.08 for analyst managers and 4.50 ($p_c<0.05$) for consumer managers. Bar charts (DG 2a) are rated as important by both manager types ($\mu_a=4.36$ to $\mu_c=4.73$), while consumer managers have a higher significance ($p_a<0.1$ to $p_c<0.01$). Regarding complementing line charts (DG 2b), consumer managers see more fields of usage ($\mu_c=4.27$) which implies a difference in working styles ($p<0.1$).

2) IS dialog control

“The smaller the devices, the fewer analysis steps are acceptable” (DG 3) is a design guideline with a high validation ($\mu_a=4.31$ to $\mu_c=4.40$), significantly for analyst managers ($p_a<0.05$). In contrast, interactive graphics (DG 3a) are highly significantly important for consumer managers ($\mu_c=4.64$; $p_c<0.01$) with differentiation between the types of managers ($p<0.05$). The “read more” function (DG 3b) has also ($p<0.1$) greater importance for consumer managers ($\mu_c=4.27$).

We offer two stereotypes of manager IS navigation (DG 4) and the managers agree to our suggestions ($\mu_a=4.31$ to $\mu_c=4.11$). The results repeat on the second layer, where the interactive navigation style (DG 4a) has a mean of 4.43 with significant importance ($p_a<0.05$) for analyst managers and 4.27 for consumer managers. The consumer working style (DG 4b) has an equal validation of both ($\mu_a=\mu_c=4.00$).

3) Functions

Exception reporting (DG 5) is a high rated function regardless the different working styles ($\mu_a=4.15$ to $\mu_c=4.22$). Even in the way to individualize their exception limits (DG 5a) and using a push-function (DG 5b), they have nearly uniform opinions ($\mu_c=4.00$ and $\mu_c=4.09$).

4) Information management

Self-service access (DG 8) is an important characteristic for new-generation managers’ in-memory apps ($\mu_a=4.15$ to $\mu_c=4.00$). In detail, consumer managers ask for accurate forecasting (DG 8b) with a mean of 4.00. Scenario techniques and simulations (DG 8c) are demanded by both working styles ($\mu_a=4.14$ to $\mu_c=4.00$).

TABLE III. EMPIRICAL DATA FOR ALL DESIGN GUIDELINES

Highlighting											
p<0.1 = one star; p<0.05 = two stars; p<0.01 = three stars						μ≥4					
DG No.	Analyst managers		Consumer managers		MWU-test AM vs. CM	DG No.	Analyst managers		Consumer managers		MWU-test AM vs. CM
	μ _a	σ _a	μ _c	σ _c			μ _a	σ _a	μ _c	σ _c	
A. Information presentation											
1	4,73 ***	0,47	4,89 ***	0,33	0,381	a	4,21	0,80	4,55 **	0,69	0,234
						b	4,57 **	0,65	4,64 ***	0,51	0,922
						c	3,86	0,95	3,55	0,82	0,236
2	4,08	0,95	4,50 **	0,53	0,309	a	4,36 *	0,75	4,73 ***	0,47	0,196
						b	3,50	1,02	4,27	0,79	0,058 *
						c	3,43	1,28	3,64	1,43	0,652
B. IS Dialog Control											
3	4,31 **	0,48	4,40	0,70	0,570	a	3,93	0,92	4,64 ***	0,51	0,025 **
						b	3,62	0,87	4,27	0,65	0,055 *
						c	3,79	1,25	3,36	1,29	0,381
4	4,31	0,63	4,11	0,78	0,557	a	4,43 **	0,65	4,27	0,65	0,522
						b	4,00	0,88	4,00	0,78	0,883
C. Functions											
5	4,15	0,90	4,22	0,67	0,971	a	3,79	1,12	4,00	0,89	0,667
						b	3,79	1,05	4,09	0,94	0,491
6	3,62	0,96	3,56	0,88	0,831	a	3,64	0,93	3,73	1,10	0,772
						b	3,57	0,85	3,73	0,91	0,698
D. Information management											
7	3,33	1,07	3,50	1,20	0,750	a	3,38	1,12	3,64	1,03	0,583
						b	2,92	1,26	2,73	1,01	0,675
						a	3,79	0,80	3,36	1,29	0,447
8	4,15	0,69	4,00	0,50	0,532	b	3,93	1,00	4,00	0,45	0,976
						c	4,14	0,77	4,00	0,63	0,589
E. Effort											
9	3,85	0,69	3,80	1,03	0,974	a	3,64	0,84	2,91	1,04	0,065 *
						b	3,86	0,77	4,09	1,14	0,386
						c	4,36 *	0,63	4,64 ***	0,51	0,263
						d	3,57	0,94	3,91	0,83	0,418

5) Effort

We conclude our questionnaire with the OLAP/OLTP merger and its effects (DG 9). The managers’ opinions are almost uniform ($\mu_a=3.85$ to $\mu_c=3.80$). Furthermore, the associated characteristics regarding timesavings (DG 9b) and new types of analysis enabled by in-memory technology (DG 9c) show similar results. Timesavings (DG 9b) are more recognized by consumer managers ($\mu_c=4.09$) but with no significant difference to analyst managers ($\mu_a=3.86$). In addition, the possibility of new analysis types (DG 9c) is highly significantly important for both ($\mu_a=4.36$ to $\mu_c=4.64$), especially for consumer managers who have a higher significance ($p_c<0.01$) than analyst managers ($p_a<0.1$).

V. INTERVIEW RESULTS AND DISCUSSION

Applying a mixed method approach (Sect. I), the second part of our research comprises qualitative feedback from one-on-one manager interviews in order to enhance the results from the workshop and demonstrate relevance. The interviews were conducted at a German automotive supplier (market capitalization: USD 33 bn; about 175,000 employees) with managers from both four group business departments and two operational business areas. Hence, we synthesized the design guidelines 1-6 for in-memory apps.

1. For the entry-page, managers prefer a tile design with a limited number of key performance indicators (KPIs). As a start screen, the results of our workshop revealed that managers want a condensed overview about their area of responsibility (DG 1). In this respect, the one-on-one interviews show that all managers, regardless of their working styles, want a tile design, exposing only the truly most important KPIs in a clear visualization. They consider a tile design (like Microsoft's Windows 8) as attractive and useful, not just for their consumer IS, but even for their business applications. In other words, the interviewed managers do not want to readjust their IS user behavior from the "old-fashioned" style of business apps in comparison to a "modern" consumer IS design. A consumer manager from the reporting and analysis department confirmed this as follows: "If even the banking app on my private mobile device is able to fulfill these requirements, why does the company reporting app fail to do so?" In another interview, an analyst manager from the corporate finance department stated that tiles stand for separated information clusters in a clear and structured form. Thus, such a tile design helps in working with KPIs from different divisions. To illustrate trends and optimize manager reports for a faster information exploration, the head of procurement said that tiles should provide symbols and use colors to show positive or negative exceptions. Furthermore, he pointed out that tiles should provide KPIs showing real-time values to trace current changes. He personally can benefit from in-memory technology through faster data processing to display real-time data. He finally said that consumer and analyst managers may have different preferences, but all managers should start with a standard report layout with the option to customize the desktop.

2. A manager news ticker provides an appropriate starting point for their self-service analysis. From our one-on-one interviews, we noted a large degree of acceptance of the news ticker feature. Especially consumer managers across the interviewed departments prefer such an overview rather than going through different reports, news journals or internal sources to find relevant information. In his interview, the head of reporting and analysis outlined examples such as net sales flashes or news from press articles about the company. Subscriptions can deliver specific information such as new technology trends. Besides the benefit of such additional information, managers should always have the option to unsubscribe from unpopular or unused information sources. In conclusion, using a news ticker "the right way", is a feature incorporated in in-memory apps to reduce in particular the ever-increasing flood of emails.

3. In-memory apps require intuitive navigation that managers already know and appreciate from the general IS consumer market. Managers prefer graphs to tables with text and numbers (DG 2). Bar charts (DG 2a) are their favorite type followed by line and pie charts (DG 2b). Especially consumer managers express a preference for such easy-to-handle graphs. More complex charts like waterfall diagrams (DG 2c) should be avoided for both analyst and consumer managers. In our one-on-one interviews, most managers revealed that they do not have favorite chart types. Rather, it is a case-to-case decision, thus we identified different use situations for the graph types outlined before. Bar charts expose histories timelines, complementing line charts, according to the interviewed head

of procurement, are used for stock prices or exchange rates, and pie charts are established for depicting shares. Another lesson learned from practice is, that especially consumer managers have a stronger preference for interactive graphics than analyst managers, because they primarily consume MSS information (Sect. II.C). Analyst managers who work primarily with tables that provide all relevant information, like to use self-service filters, drills, as well as sorting (DG 4a) for a more detailed view.

Furthermore, we evidence that managers accept only a limited number of analysis steps (DG 3), especially on smart devices. Almost all interviewed consumer managers argued for limited operation capabilities when mobile, desiring easy-to-handle touchscreens without a keyboard or mouse. The vice president of the tires division concluded that the higher managers' position in the company is, the less they will accept a series of navigation steps. Another manager feature is a "read more" button (DG 3b) that shows information only if needed and requested. Information on demand is a way to leverage the reduced space on smart devices. We observed that consumer managers perceive this feature as more useful. Another two complementary functions for ensuring intuitive navigation are bookmarks for frequently used single items of information, information sections or complete reports, and "breadcrumbs" that allow rapid navigation between different levels of detail.

4. A collaboration tool fosters joint managerial problemsolving. In contrast to the results of our workshop with an average approval to the usefulness of collaboration tools (DG 6), we learned from the interviewed managers that collaboration tools are already established in companies. They are used for ad-hoc communication about charts or significant numbers from reports. Thus, we propose collaboration tools on demand (DG 1c). In contrast, company blogs or forums, in which employees chat about their leisure time activities are not requested. Furthermore, managers do not want to administer various contact lists, whereas IT department does not want to maintain two or more tools and data stocks. Thus, we propose a strict alignment between existing collaboration tools and a new MSS collaboration tool.

5. Exception reporting which includes personal exception limits and a push function helps managers to react faster. Exception reporting (DG 5) with individual exception limits and a push function was examined as a "must-have" for in-memory apps. Managers want to react quickly (in real time) to critical changes, even when they are mobile (DG 5b), but they do not want to be bothered with unnecessary information (DG 5a). Regarding exception reporting, the head of financial accounting revealed that it is important to separate such alerts from ordinary emails, because they will otherwise get lost in the day-to-day email flood. He proposes to highlight such exceptions in order to provide information to the point and, thus, faster information exploration.

6. Apart from "pure" financial aspects, the benefits of in-memory technology should be evaluated by their capability to perform new MSS topics of analysis. Cost savings often dominate the implementation of new IS technology. However, this limitation could lead to companies missing the benefits of new IT enablers (DG 9a). The results from the

workshop reveal timesaving potential for present data analysis (DG 9b) and a very high level of potential for new types of analysis (DG 9c). The analyst managers consider IS self-service (DG 8) with new types of analysis for forecasting (DG 8b) and extensive simulations for future market situations (DG 8c). Finally, all managers would like more drill-throughs, which means detailed analysis with parameter transfer from MSS to ERP systems, e.g., for accounts receivable or accounts payable, i.e. a more effective connection of existing reports to enable a better understanding of problem correlations.

VI. OUTLOOK AND AVENUES FOR FUTURE RESEARCH

In-memory technology is a new IT enabler and many companies consider such apps incorporated into MSS for manager self-service. Besides the technical aspects of reducing time for MSS data entry and analysis, such apps lack impact from a manager perspective. Hence, this paper proposes guidelines for an in-memory app design from a manager perspective, thus contributing to greater MSS acceptance.

For *practice*, the proposed design guidelines provide specific recommendations for IS designers as a means of improving MSS through incorporating an in-memory app design from a manager perspective. To do so, we differentiate between both analyst and consumer managers. For *research purposes*, the proposed guidelines provide a rigorous starting point for future investigations on in-memory app design for managers as we examined different determinants of in-memory app design that influence the perceived usefulness of managers' day-to-day interactions with MSS.

Examining in-memory apps from a manager perspective exposes several avenues for future research. Managerial working styles and their influence on app design should be specified in detail. Gender, the level of expertise, IS experience, and past device usage patterns may all be important. The limited number of workshop members and interview partners in our study may lead to biased results. A *survey* with a greater number of managers, even if they include some smaller companies, should provide a more solid basis. To support the "build and evaluate" perspective of DSR, a subsequent design cycle should even include *instantiations*, for example within a multi-case study. Another avenue for research is to build a *prototype* to drive managers' awareness of new topics relating to MSS in-memory analysis and to examine their perceived usefulness. Assuming that the technological progress for managers' IS support will maintain its pace, mobile solutions will be more and more on their agenda. Thus, mobile IS for managers will create new use cases for MSS design that leverages in-memory technology. Therefore, our guidelines need to be updated as the related technology evolves.

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