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ABSTRACT

In web stores, a large amount of product information is easily available for consumers. This often leads to information overload on the consumer-side which decreases user-satisfaction and can cause purchase deferral. Therefore, our goal is to prevent consumers from information overload by supporting the cumbersome process of comparing and evaluating products. We propose easy to understand, interactive decision aids, called interactive information management tools such as filtering, sorting and scoring. The contribution of this paper is to (1) retrieve guidelines for designing such tools from both literature on decision behavior research and information systems, and (2) build a prototype following these guidelines. The prototype is evaluated in two usability studies.

Keywords

E-Commerce, Consumer Behavior, Interactive Decision Aids, Interactive Information Management Tools, Decision Support, Design Science

INTRODUCTION

Despite the economical breakdown, Forrester's online retail forecast predicts that US online retail sales will reach $229 billion in 2013 and an annually growth of market of 10% from 2008 to 2013 (Evans, Sehgal, Bugnaru and McGowan 2009). One major role which information systems can play with respect to online purchases, is to design systems that optimally support consumers in the purchase process and thus, increase consumers' satisfaction and, in turn, the revenue of online sellers. Interactive decision aids (IDA) are tools which "help consumers in making informed purchase decisions amidst the vast availability of online product offerings" (Wang and Benbasat 2009, p. 3).

Until now, most researchers in information systems have proposed recommendation agents, as one possible form of IDA. "Recommendation agents are software agents that elicit the interests or preferences of individual users for products, either explicitly or implicitly, and make recommendations accordingly" (Xiao and Benbasat 2007, p. 137).

Besides recommendation agents, interactive information management tools (IIMT) have been introduced as one further type of IDA. IIMT assist consumers to compare and evaluate different products and help to sort products, eliminate products through filters, and do in-depth comparison in product-comparison matrices (see Figure 1 with such a matrix) (Gupta, Manjit and Varadarajan 2009; Pfeiffer, Riedl and Rothlauf 2009). Hence, in contrast to recommendation agents which focus on preference elicitation and provide recommendations, IIMT focus on comparing product information.

In other work, we provide first empirical evidence that consumers prefer IIMT to recommendation agents (Pfeiffer 2010). Even though there is rich literature in the field of consumer research and information systems on how consumers behave and how IDA should be designed, there is no attempt so far to systematically design IIMT. Hence, the goal of this paper is to (1) retrieve design guidelines from both literature on decision behavior research and information systems, (2) build a prototype in form of a modular system following these guidelines, and (3) evaluate the design of the prototype in two usability studies.

The advantage of our approach is that it ensures research rigor, and, at the same time, designs a relevant IT artifact (refer to design science approach by Hevner, March, Park and Ram 2004). We ensure research rigor by pursuing the following approach: (1), we review literature on theory of decision behavior from psychology and consumer research to explain main characteristics of decision behavior. (2) , we refer to literature on information systems which discusses drawbacks of existing IDA and the resulting requirements for better decision aids. Grounded on these results, we suggest and implement a set of IIMT that support decision behavior as described in (1) and follow design guidelines as obtained in (2). Finally, we provide some prior empirical evaluation of the designed IIMT in two usability studies.

BACKGROUND ON DECISION BEHAVIOR RESEARCH

When purchasing a product, consumers face a decision problem: they have to choose a product among the vast variability of available products which best fits their needs. Many empirical studies have demonstrated that in such decision problems, decision makers follow a systematic process and use so-called decision strategies (Johnson and Payne 1985). Decision strategies define "a sequence of operations used to transform an initial stage of knowledge into a final goal state of knowledge in which the decision maker feels that the decision problem is solved" (Payne, Bettman, Coupey and Johnson 1992, p. 109). One famous example is using the multiattribute utility model (MAU) which describes the process of choosing the alternative with the highest weighted sum of the attribute-utilities (Anderson 1974). Another, much simpler decision strategy, is the lexicographic rule (LEX) which chooses the alternative with the best value on the most important attribute, e.g., the product with the lowest price (Fishburn 1974).

In order to provide appropriate decision support which is accepted by users, users should experience a good fit between the decision strategy they want to apply and the decision support offered to them. There is a lot of research in psychology and consumer decision behavior that analyzes which decision strategies decision makers apply when deciding for or against an alternative (Ball 1997; Bettman, Johnson, Luce and Payne 1993; Gilbride and Allenby 2004; Gilbride and Allenby 2006; Payne, Bettman and Johnson 1993; Swait and Adamowicz 2001). Hence, when designing a decision support system which assists purchase decisions, this knowledge on decision behavior can be taken into account. Also Al-Natour, Benbasat, and Cenfetelli (2008) found that IDA had positive effects on usefulness and trustworthiness when their process was perceived to be similar to the one of the users (see, however, Aksoy and Bloom 2001).

We now describe characteristics of decision strategies which best describe peoples' decision behavior (Riedl, Brandstätter and Roithmayr 2008; Shao 2006). This will help to determine the kind of decision support that is needed. In the description we use the term *attribute level* for referring to product features such as black, white or red color or small, medium or large size and attribute values reflect the decision maker's utility for that attribute level.

Aspiration levels (yes/no): In some strategies, attribute levels are compared to aspiration levels (or cutoff-values or thresholds). A maximum price we are at most willed to pay for a product would be an example for an aspiration level.

Attribute weights (yes/no): Attribute weights express how much each attribute influences a decision. A high weight on price, for instance, shows an emphasize on the price of the product.

Attribute vs. alternative-wise: A strategy can induce an attribute or an alternative-wise comparison. Attribute-wise comparison describes a decision maker who picks one attribute, compares its attribute levels across all alternatives and then moves to the next attribute. Comparing all products first regarding their color and then regarding their price is an example for attribute-wise processing. Alternative-wise strategies, in contrary, assume the decision maker to first evaluate a complete alternative regarding all its attribute levels.

Compensatory versus non-compensatory: In compensatory strategies, a low value of an attribute of a product can be compensated by a high value on a different attribute. A typical statement of a consumer applying a compensatory strategy would be "I would prefer a cell with integrated navigation system, but not if I have to pay too much extra for that". In contrast, in non-compensatory strategies (e.g., LEX) such compensation is not possible as negative attribute levels cannot be traded-off by positive ones.

Consistency across attributes/alternatives: A consistent decision strategy evaluates the same amount of attribute levels per attribute/alternative.

Complete versus selective: A complete decision strategy considers all product information (all attribute levels). Therefore, each complete decision strategy is automatically consistent.

Elimination (yes/no): Some decision strategies eliminate alternatives to narrow down the choice set until only one final choice is left. Others choose the alternative by assigning a value to each one and choosing the one with maximum value.

Pairwise comparison (yes/no): Some strategies compare alternatives sequentially in pairs. Usually they eliminate the weaker alternative of that pair and keep the stronger alternative for forming a new pair.

Qualitative versus quantitative reasoning: Quantitative strategies require counting, adding, or multiplying attribute values while qualitative strategies simply compare attribute levels. Attribute values can either be compared to aspiration levels or attribute levels can be compared to one another.

REQUIREMENTS RETRIEVED FROM LITERATURE ON INTERACTIVE DECISION AIDS

In a recent review on IDA, Murray and Häubl (2008) observe that recommendation agents have disappeared. They point out several barriers which have to be overcome for a successful adoption of IDA. First, they conclude that more consistent tools are needed. Second, recommendations often contradict users' preferences. That is because a certain preference model or notion of what constitutes a high-quality decision is assumed by the system and does not correspond to the users' conception. Third, predictions on the consumers' purchase behavior and preferences are non-reliable because of the constructive nature of preferences (Bettman, Luce and Payne 1998; Simonson 2005). Preferences are believed to be constructed rather than stable. First, they are most commonly constructed only when users are asked for their actual evaluations and, second, the construction process is shaped by the users' information processing system and the properties of the choice task (Payne, Bettman and Schkade 1999). Forth, consumers have privacy concerns to reveal their preferences to the systems. Fifth, the consumers might feel that the costs of using the IDA outweigh the benefits if IDA are difficult to use. Sixth, even if web pages did offer more IDA to the user, a new problem would arise. Offering a number of IDA adds a next complexity level to the choice since users have to decide not only for a product but also which decision aid to apply.

We retrieve several design requirements from this review. First, the IDA should have a consistent design. Furthermore, it should be flexible in that they support several preference models and allow changes in the model. One approach to achieve this goal is to offer IDA which support the application of a diverse set of different decision strategies which rely on different preference models. Flexibility also incorporates the idea that the consumer can stop revealing preference information any time during the process. This approach also prevents conflicts with privacy issues as decision makers only have to reveal as much information as they like. Moreover, preferences should be elicitated when the information of the actual products is already known because of the constructive process of preferences. People find it easier to construct a model of their preferences when considering examples of actual alternatives (Payne et al. 1999). This is evidence in favor of letting decision makers choose the product out of the product-comparison matrix where all information on alternatives can be displayed and compared easily. Further, IDA should be easy to use and intuitive in order to minimize the effort for using the aid itself. For instance, the web page can be adapted to the needs of consumers and the given environment by only offering those aids which are needed for the decision, in order to reduce the cognitive burden to choose one of many offered IDA.

From other studies, similar design requirements can be retrieved. In an empirical study, Ariely (2000) shows that letting the consumers control content, order and duration of product relevant information results in higher value, increases usability of information and confidence. However, when cognitive load is high, too much control might be harmful. As guideline from this study, we retrieve that IDA should have a high degree of control. Nevertheless, as mentioned above, in complex situations, control and interactivity should be reduced for instance by offering only those aids which optimally support users in the particular situation.

Pereira (2000) also recommends high user control and an adaptive system. They have shown empirically that respondents react positively when they have more control on the decision aid. For instance, they can skip answers, jump back and forth, and express their degree of confidence.

Spiekermann and Paraschiv (2002) state that current systems lack communication in that the user is only allowed to retrieve certain preference information, such as attribute weights. Second, the systems do not adapt to the users' level of expertise. We think that offering the flexibility to support several decision strategies will reduce both problems as each consumer can apply the decision aid that naturally fits to the preferred decision strategy. Furthermore, the authors discuss that the user cannot see the logic behind the system. Again, we think that transparency of the process by directly observing the effects of applied IDA on the matrix is a way to circumvent this problem.

In their model, Gretzel and Fesenmaier (2006) examine the influence of three cues (relevance, transparency, and effort) on the perceived value and enjoyment of the decision process for recommendation agents. Their results show that transparency and effort had highest influence on perceived value, while the relevance of questions asked to the users (product-related vs. non product-related) has low impact. Furthermore, low effort seems to increase the value but decrease enjoyment of the decision process. Therefore, the authors suggest that when designing IDA the conflictive impact of effort should be taken into account. From our viewpoint, this can be achieved by allowing the user to control the degree of decision support and hence, to control the degree of effort reduction.

In sum, we can retrieve six requirements for designing IIMT from literature on IDA:

Adaptivity**:** Adapt the interface to the environment and users' needs and characteristics such as expert vs. novice users.

Consistency**:** Provide the results of users' interaction through a consistent interface.

Control: Let the user control the interaction.

Flexibility**:** Allow users to fully control the process and to be able to stop the interaction at any time. Modularize the offered IDA such that modularization allows users to switch between different strategies easily.

Low Effort**:** Make interface intuitive and minimize cognitive effort of choosing.

Transparency**:** Make the actions of the IIMT transparent and comprehensible. Immediately show effects of users' actions.

PROPOSED INTERACTIVE INFORMATION MANAGEMENT TOOLS

Designing a modular system

In order to fulfill the requirements, we use guidelines from research on human-computer interaction. We strive for ***consistency*** by applying standardized terminology, abbreviations, formats, colors, fonts and capitalization (Shneiderman and Plaisant 2009; Smith and Mosier 1986). In addition, we require consistent sequences of actions by users when encountering similar situations. We will ensure ***transparency*** by allowing direct manipulation. Direct manipulation is defined by visual representation of objects and actions, as well as rapid, reversible, and immediately observable execution of pointing actions (Shneiderman 1983). Hence, we refrain from questions and answer dialogs or other preference elicitation processes which hide the process from the user and would make decision support non-transparent. In order to modularize the decision support and allowing for ***flexibility***, we ensure that the different IDA support the nine characteristics of decision strategies as described above. From our viewpoint, this approach also helps to achieve ***low effort*** because the IDA are directly derived from empirically observed decision behavior and should be intuitive to use. Moreover, the set of IDA has to provide full ***control*** which information is displayed, how it is displayed and how users want to compare and evaluate the products. Hence, the user should feel a high information control in contrast to other systems where products are recommended by some kind of non-transparent evaluation steps on the system side (e.g., recommendation agents).

The following table provides an overview of the IDA, which we suggest, and the characteristics they support. In order to distinguish our modular system from recommendation agents, we follow Gupta et al. (2009) and call them interactive information management tools (IIMT).

IIMT	**Characteristic**	**Description**
PAIRWISE COMPARISON	pairwise comparison	Allows two alternatives to be compared pairwise.
MARK	attribute-wise process, aspiration levels	Highlights differences and similarities of products along one attribute. Indicates whether an attribute level is above (positively marked) or below (negatively marked) an aspiration level.
REMOVE	Elimination, aspiration levels, selective, inconsistent	Removes an alternative from the matrix. As there are two strategies which remove alternatives which do not meet the aspiration level on at least one attribute. A remove of alternatives with at least one negatively marked attribute level should further be possible.
FILTER	Aspiration levels, elimination, selective, inconsistent	Removes all alternatives which do not meet the aspiration level on an attribute. Thus, alternatives can be excluded from further consideration without having considered all available information.
SCORE	Compensatory, attribute weights, quantitative	Quantifies the extent to which an alternative has positive and negative values. The score can be used to trade-off attribute levels against each other.
CALCULATE	Compensatory, quantitative	Given the scores for several attribute levels and the assigned attribute weights, calculations of these values is necessary.
SORT	Attribute weights	Sort attributes/alternatives.

Figure 1. First design of IIMT.

In another work, Pfeiffer et al. (2009) have analyzed that out of the existing 17 decision strategies MARK, supports 11, REMOVE 8 and CALCULATE 7 different strategies. Thus, these seven IIMT build a modular system with a high degree of reusability as many decision strategies are supported by the same IIMT.

The design of an adaptive system must be left to future work as making the decision support system adaptive to different users and environments, goes beyond the scope of this work. However, we would like to note that the modularity of the system facilitates adaptivity as the online store can hide the subset of IIMT that are not needed by the particular user and the particular decision environment.

Implementation

Figure 1 shows the implemented system with an example of 5 cell phones. The design of the system is based on ideas introduced in Pfeiffer et al. (2009). At the top, the IIMT REMOVE and SORT are placed. At the left hand side, users can specify aspiration levels with a FILTER. In the product-comparison matrix itself, in the middle of the screen, users can use SCORE by assigning stars to attribute levels. At the top of each column the final SCORE is computed by choosing the appropriate CALCULATE option. The small cross can be used to MARK attribute levels as negative (crossed out). Furthermore two products can be compared PAIRWISE by using the two checkmarks at the bottom of the product pictures. At the top of each product picture and at the left hand side of each row, REMOVE is offered for deleting products from the matrix or minimizing rows.

The system was programmed with the AJAX framework and the JQUERY library. The product data is stored in a mySQL data bank and retrieved via php.

Evaluation – Study 1

For evaluating the IIMT, we conducted one usability study with experts and one with both experts and non-experts. For the first study with experts, we took a brainstorming approach and followed a three-step process: (1) fact finding, (2) idea finding and (3) solution finding (Osborn 1963).

The study started with an introduction to the overall software project. The experts were five faculty members who had knowledge in the field of interactive decision aids and software development. In phase (1), the experts had the opportunity to explore the IIMT. No introduction of the IIMT functionality was provided in order to observe in how far they are self-explaining. In phase (2), the experts answered a short questionnaire with open formulated questions on their first impression and their ideas for improvement. Furthermore, we asked for evaluations of the five design criteria: consistency, control, flexibility, low effort, and transparency[1]. In phase (3), the results of the first two phases were recapitulated and the group discussed possible solutions.

The main points of critique were:

1. Overcrowded and confusing design which overstrained the users, and
2. Uncertainty about the functionality of some IIMT and their actions when using them.

Experts stated things like “What happens when I mark an attribute level red?”, “It was unclear what to do with all the stars.”, or “I am overstrained.”, and “Too much stuff!”.

In the third phase the following solutions were suggested for addressing these problems:

1. Redesign filter to improve clarity and consistency: remove apply button, add unities, use less dominant colors, unify font type, show already filtered attribute levels at the top of filter.
2. Change the way attribute levels are displayed in the table: make rows more cohesive, improve readability of attribute levels, remove vertical lines.
3. Replace parts of IIMT with symbols already known from well-known operation systems, such as “+” and “-“ for maximizing and minimizing menus.
4. Add help functionality to explain decision aids.

Based on the results of this first usability study, the IIMT were improved and tested in a second study, which we will describe in the following section.

Evaluation – Study 2

Having received enough input from the round of experts in the first study, the system of IIMT was tested also with non-expert users. As method, we chose thinking aloud protocols (Ericsson and Simon 1980; Shapiro 1994). Thinking aloud require users to verbalize their thought processes as they perform a certain task with the system (Jorgensen 1990; Woods 1993) and are thought to be one of the most valuable usability engineering methods since they are a close approximation to the individual usage and the data can be collected from a fairly small number of users (Nielsen 1994).

We followed the five guidelines by Buber and Holzmüller (2007) which state that instructions should be formulized, an appropriate experimental setting must be established, means for keeping up the think-aloud process must be undertaken, the user should talk about their experiences and technical problems should be kept to a minimum.

The usability test was conducted with seven subjects, among them four women and three men. According to the users’ self-reports, two of them had little technical experience, and one of them stated to never have been purchased a product online before. Two of the users were computer scientists and therefore experienced with dealing with interfaces.

To all subjects, we read aloud an introduction at the beginning of the study. The study was conducted in a comfortable, calm room of the university which is familiar to the subjects. The subjects had to imagine that they were shopping online for cell phones and had already chosen five cell phones of highest interest to them. They were instructed to test the functionality of the IIMT first, before they were going to actually choose one of the products. This approach helped us to observe users’ interaction with the different kind of IIMT. During the actual study, no further assistance was provided by the conductor. The subject’s statements as well as their clicking behavior were recorded with Camtasia Version 6 by TechSmith and an additional audio recorder.

After the subjects had used all IIMT, recording was stopped and they had to answer a questionnaire asking for evaluations of the three constructs: consistency, control, and transparency. The questionnaire was designed with 3-5 items known from literature for each of the constructs (Ariely 2000; Kamis and Davern 2005; Pereira 2000; Wang et al. 2009). We did not yet ask for the evaluation of the two constructs low effort and flexibility as we wanted the subjects to evaluate these two aspects only after they had actually chosen a product. Hence, after having answered the questionnaires, we recorded again subjects’

[1] As stated above, our software does not yet incorporate the idea of adaptivity.

thoughts while they actually chose a product and handed out a second questionnaire regarding questions concerning low effort and flexibility.

In total, 23 errors or missing functionalities were found by the users:

- *3 Logical errors of the system*: for instance the same attribute level can be evaluated with different scores
- *5 Programming bugs*: for instance distorted display if certain IIMT were used in sequence
- *8 Weaknesses of the design*: for instance sliders in the filter were too small and unrecognizable for users
- *7 Missing functionalities:* for instance, minimize and maximize all attributes with one click

Figure 2 summarizes the average frequencies each item of the five design criteria were rated as either positive or negative. For measuring transparency, for instance, we asked for the following three items: "I was always aware which IIMT would cause an action and which wouldn't", "It was obvious what would happen, after I had used an IIMT", "My input caused an immediate reaction on the website". Over all these three items, in average we counted 1.67 (strongly agree), 4 (agree), 1.33 (disagree), 0 (strongly disagree). All other design requirements as well got positive evaluations as no requirement had more than 2 negative ratings (disagree and strongly disagree) out of the 7 possible ratings by the 7 users. The best ratings achieved the flexibility and the perceived effort. Thus the system seems to positively affect flexibility and effort.

To further improve the IIMT and achieve more positive user evaluations error corrections and suggestions were implemented in further six weeks of programming. The resulting design of the IIMT is displayed in Figure 3.

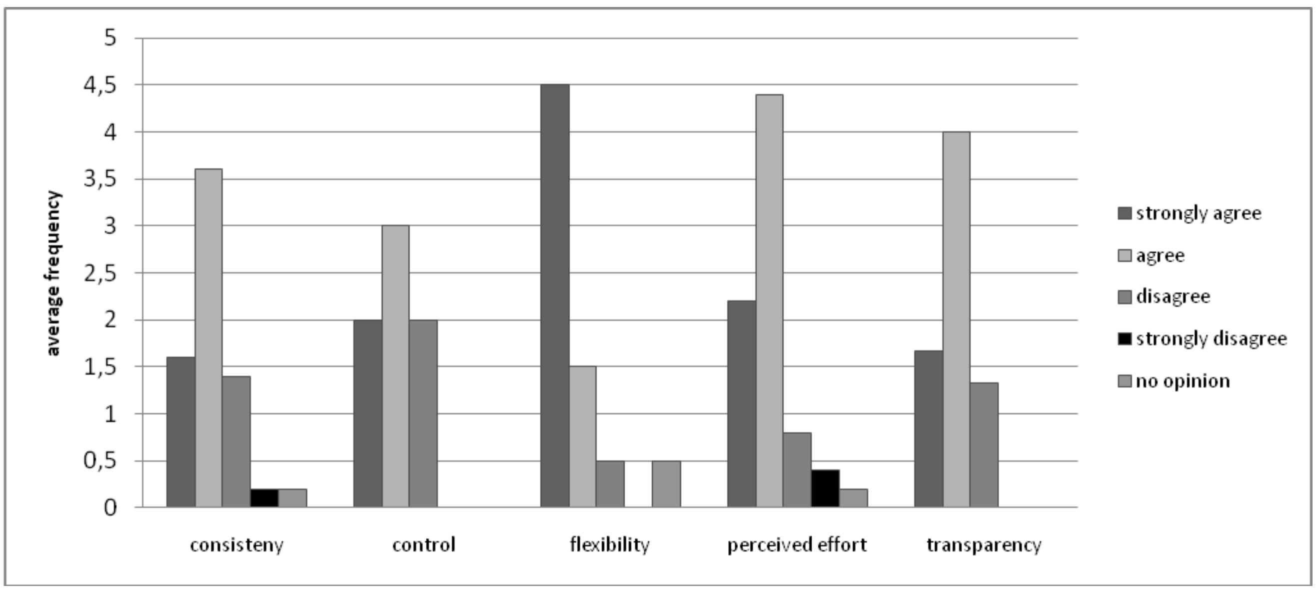

Figure 2. Evaluation of the five design criteria retrieved from the Think-Aloud study.

CONCLUSION

We have shown how to design a decision support system in a theory-based approach implementing requirements gained from behavioral research on decision behavior. We think that the approach of tailoring decision support systems tightly to the users' needs and natural decision behavior, will improve consistency, control, flexibility, perceived effort and transparency. First steps have been described in this paper. We implemented a decision support system for product purchase decisions and two qualitative usability studies. In the future, we will do a quantitative experimental laboratory study to further evaluate the proposed system. Interesting aspects to consider will be to test other factors influencing users' satisfaction, learn from users' clicking behavior about their decision behavior, vary the number of products shown per screen, and test in how far adaptive versions of the modular system can further improve users' satisfaction.

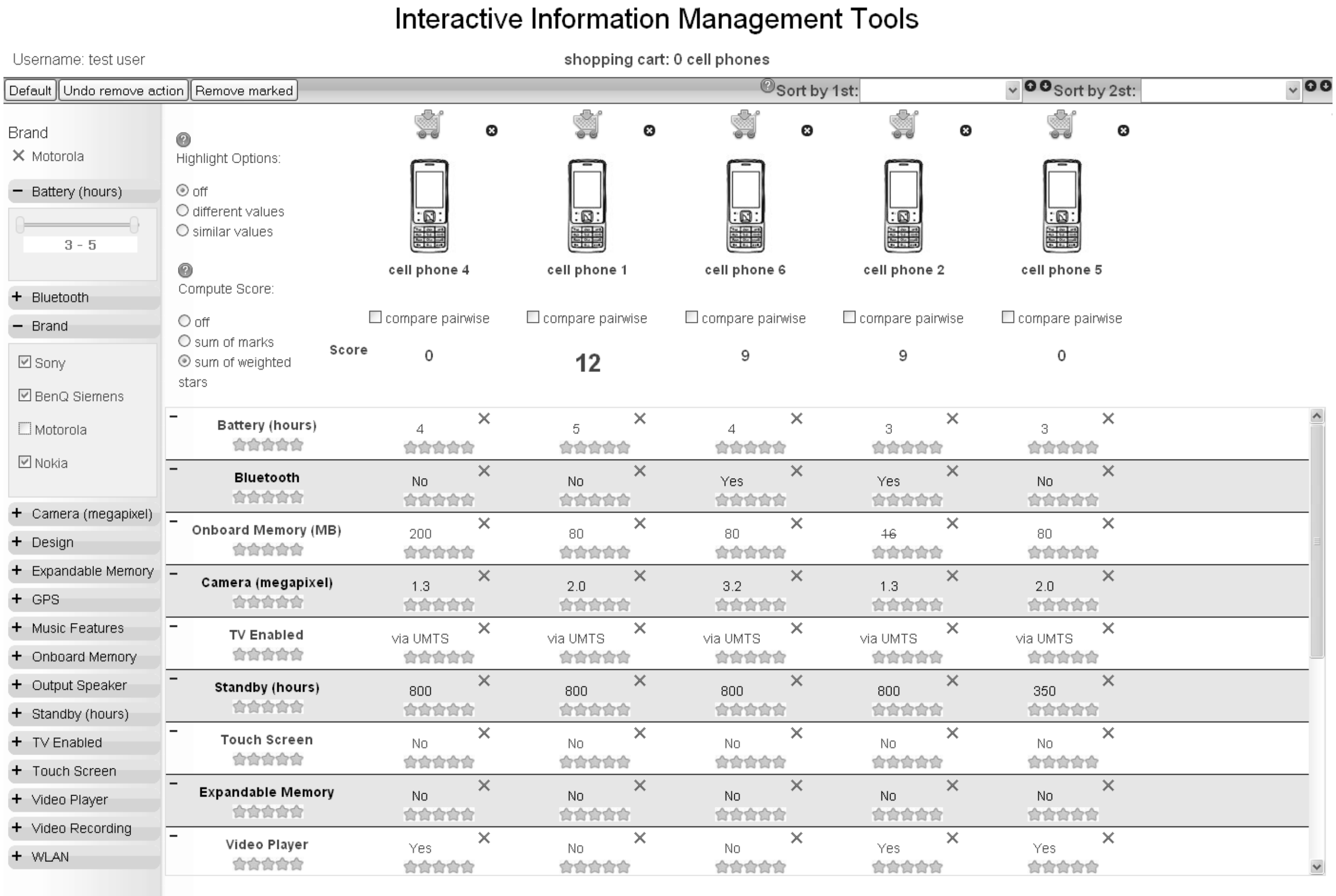

Figure 3: Final design of the system.

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