Just Like Paper: A classification system for eVoting Machines

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Abstract: This work presents a classification system for commercial electronic voting machines. We term this classification system the 'Just-Like-Paper' or JLP classification. We are particularly interested in incremental differences in functionality between voting systems and how that functionality differs from 'traditional' pen and paper based voting. We successfully applied the JLP classification to the ongoing development of our novel DualVote eVoting system where its application led to the development of a passive feedback protocol.

Keywords: ICT, Classification, eVoting, Usability

Acknowledgement: The authors would like to acknowledge the funding support of Enterprise Ireland. The authors would also like to thank Ted Scully and Francis Carmody for their valuable input.

Introduction This paper emerges from previous work on a novel e-voting system which we have developed called Dual Vote. (MacNamara et al., 2010), (MacNamara et al., 2011), (Gibson et al., 2011). With Dual Vote, a voter's preference is simultaneously recorded on both electronic and paper media. The Dual Vote system allows a user to cast a vote using a pen and paper interface and simultaneously records the vote electronically using an optical sensor array and a capacitive-based electronic pen. Previously, classification models have been deveoloped for eVoting schemes based on differing criteria. One such classification defines systems based on how the voter submits their vote to the tallying authority. Systems are classified by: Hidden voter (anonymous voter) hidden vote (encrypted vote), hidden voter with hidden vote. (Sampigethaya et al., 2006). Other research has classified privacy and verifiability requirements in an attempt to define such requirements of eVoting systems in less formal language while retaining precision. (Langer et al., 2009). Recent previous work in this area has also looked at commercial systems based in the US while including those intended for disabled voters. The work offers a classification structure based around four 'tiers' namely: Core technology, components, voter interface and ballot presentation and is termed the Electronic Voting Classification Structure (EVCS). The motivation for the work was to create a 'common language' for eVoting systems technology which may help in the procurement and classification of such systems. Franklin and colleagues omit remote based voting systems but include significant work in this area in the US Election Assistance Commision's Survey of Internet Voting (Franklin et al., 2012). As we were developing a full commercial eVoting system, with particular emphasis on a novel pen and paper interface, we did not consider technologies for disabled voters. Additionally, we omit remote voting technologies from the classification.

2. JLP Classification

During our work on the most recent DualVote prototype, we wished to extend the functionality of our system without weakening our most fundamental requirement. To this extent, we analyzed the interface features of twenty-six commercial systems and ordered them within a feature based classification. Each system was then ranked in accordance with the number of interface features that it had in common with a pen and paper baseline. The baseline system that we chose is that of the current pen and paper system used in the Republic of Ireland where the voter uses a pen and paper to cast their vote before depositing the paper ballot in the ballot box. It is completely non-electronic. Ultimately, our goal is to develop our DualVote system to the extent where the usability of pen and paper is preserved while having some of the extended functionality of electronic voting. The JLP classification thus starts with systems which are most like our baseline. To rank the systems, we use the postfix JSN followed by a number. Our baseline system is therefore JSN1. The next classification - JSN2, builds on the functionality of JSN1 while sharing some of its features and so on. The higher the system classification the less the system has in common with the baseline but the more functionality that it offers.

3. Specification of Interface Features

We identified five broad categories of interface features: Error-Feedback, Ballot-Confirmation, Machine-Activation, Duality Generation and Interface Modality.

Error-Feedback. This is the ability of the eVoting system to provide feedback to the voter in the case of a detected voter error. We have identified two subcategories of error-feedback:

I. **Basic Feedback.** Basic feedback occurs when the vote is only accepted or rejected by the voting machine. No further information is given to the voter. For example, some voting machines will return the ballot paper via the optical scanner interface if an error is detected on the ballot but no further information is given to the voter.
II. **Detailed Feedback.** Detailed feedback occurs when the voter is told why their vote was rejected by the voting machine. For example, some voting machines will print out a detailed report of the errors made by the voter on the ballot paper.

Ballot Confirmation. This interface feature category refers to all aspects of the interface which allow the voter to confirm the electronic interpretation of their vote before it is cast. Some optical scan systems will only ask the voter to confirm their vote once there are detected errors on the ballot - this is often coupled with detailed feedback which gives an explanation for the ballot rejection.

Machine Activation. An activation interface activates the voting machine. This is done by either the voter or the poll-worker. On optical scan systems, the ballot paper activates the voting machines once it is inserted into the scanner. Therefore the scanner has a double function; firstly to activate the machine and secondly to interpret the vote. We can therefore define a subcategory of machine activation:

I. **Dedicated Machine Activation.** On some systems, the machine is activated when the voter inserts a ballot into the optical scanner on others the voter is required to insert an 'activation token' into a specific port or slot on the voting machine in order to activate it. This port/slot is not used for any other purpose and is therefore a 'dedicated' activation interface.

Duality Generation. This is the ability of the eVoting system to generate another copy of the vote (from paper to electronic or from electronic to paper). Duality Generation is further broken down into two subcategories:

I. **Simultaneous Generation.** This refers to the generation of a paper vote and electronic vote at the same time.
II. **Multiple Generation.** This refers to the generation of an electronic vote or paper copy through multiple user actions (for example; touch-screen then printing or writing and then scanning).

Interface Modality. This refers to the number of interfaces that a voter must interact with in order to generate their vote. Most systems require a single user interface and are 'uni-modal' however a few systems are 'multi-modal' requiring the voter to interact with more than one interface. One further distinction for interface modality is the use of non-standard interfaces which are classified as follows:

I. **Standard and Non-Standard Interfaces.** We define a standard interface as one the following: Touch-screen, Push-button, Pen and Paper. We have encountered some interfaces which we describe as 'un-common' or non-standard in eVoting systems. For example: Navigation-dial, Vote-recorder apparatus, Pen-stylus for touch screen.

From our review of the eVoting systems we found fourteen distinct interface features (IF) of eVoting interfaces which fall under the various five broad categories.

Error-Feedback

IF1: No feedback interface features. The voter will receive no feedback if an error is detected on the ballot;

IF2: Basic feedback interface features. The voter will be informed that an error has occurred without any information concerning the type of error;

IF3: Detailed feedback interface features. The voter will be informed that an error has occurred and is provided with additional information concerning the type of error;

Ballot-Confirmation

IF4: No ballot confirmation interface features. The voter is never required to confirm their vote;

IF5: Error-related confirmation interface features. The voter is required to confirm their vote only when an error is detected on the ballot;

IF6: Compulsory confirmation interface features. The voter is always required to confirm their vote;

Machine Activation

IF7: No dedicated-activation interface is present or the poll-worker activates the voting machine;

IF8: A dedicated-activation interface is present.

Duality Generation

IF9 Interface features support simultaneous vote generation;

IF10: Interface features support duality generation with multiple voter actions;

IF11 No duality generation interface features are present;

Interface Modality

IF12: The vote creation interface is uni-modal;

IF13: The vote creation interface is multi-modal;

IF14: The interface features consist of a non-standard interface technology or apparatus.

IF14	IF13	IF12	IF11	IF10	IF9	IF8	IF7	IF6	IF5	IF4	IF3	IF2	IF1	Common Feat.	Diff. Mag	Classicication
0	0	1	0	0	1	0	1	0	0	1	0	0	1	5	0	JSN1
0	0	1	0	0	1	0	1	0	0	1	0	1	0	4	1	JSN2
0	0	1	0	0	1	0	1	0	1	0	0	0	1	4	1	JSN3
0	0	1	0	0	1	1	0	0	0	1	0	0	1	4	1	JSN4
0	0	1	0	1	0	0	1	0	0	1	0	0	1	4	1	JSN5
0	0	1	0	0	1	0	1	0	0	1	1	0	0	4	2	JSN6
0	0	1	0	0	1	0	1	1	0	0	0	0	1	4	2	JSN7
0	0	1	1	0	0	0	1	0	0	1	0	0	1	4	2	JSN8
0	0	1	1	0	0	0	1	0	1	0	0	0	1	4	3	JSN9
0	0	1	0	0	1	0	1	0	1	0	0	1	0	3	2	JSN10
0	0	1	0	0	1	1	0	0	0	1	0	1	0	3	2	JSN11
0	0	1	0	0	1	1	0	0	1	0	0	0	1	3	2	JSN12
0	0	1	0	1	0	0	1	0	0	1	0	1	0	3	2	JSN13
0	0	1	0	1	0	0	1	0	1	0	0	0	1	3	2	JSN14
0	0	1	0	1	0	1	0	0	0	1	0	0	1	3	2	JSN15
0	0	1	0	0	1	0	1	0	1	0	1	0	0	3	3	JSN16
0	0	1	0	0	1	0	1	1	0	0	0	1	0	3	3	JSN17
0	0	1	0	0	1	1	0	0	0	1	1	0	0	3	3	JSN18
0	0	1	0	0	1	1	0	1	0	0	0	0	1	3	3	JSN19
0	0	1	0	1	0	0	1	0	0	1	1	0	0	3	3	JSN20
0	0	1	0	1	0	0	1	1	0	0	0	0	1	3	3	JSN21
0	0	1	1	0	0	0	1	0	0	1	0	1	0	3	3	JSN22
0	0	1	1	0	0	1	0	0	0	1	0	0	1	3	3	JSN23
0	0	1	1	0	0	1	0	0	1	0	0	0	1	3	4	JSN24
0	0	1	0	0	1	0	1	1	0	0	1	0	0	3	4	JSN25

Figure 1 A Sample JLP Table

From the table we can see that there are two extra columns next to the classification number. The first column labeled 'Diff. Mag' refers to the difference magnitude or by how many features is this system different from our baseline. The column next to this is called 'Common Feat.' or Common Features; referring to how many features this system has in common with our baseline. We add these columns in to make clearer distinctions between classifications so the JSN will more closely represent the differences in functionality between systems.

5. Conclusion

The JLP classification can potentially be used to show how commercial systems incrementally differ from each other in terms of functionality and subsequently how each system differs from our baseline. The JLP was instrumental in helping us to understand how we could build on the usable but less functional DualVote system. It helped us to further classify voter feedback, confirmation, activation, paper audit trail technologies and the vote creation interface in itself. We found our system lacking in terms of feedback and confirmation but somewhat advantageous in terms of duality generation, activation and interface modality.

The JLP classification is an initial attempt to classify systems in terms of interface features and functionality. With some work, we believe it could be applied to usability. It may be interesting to explore the number of ideal actions for each voting system and apply it to the classification. We are aware that this has been done on a smaller scale in other work (Conrad et al., 2009). It may be already feasible to deduce that a machine with a lower classification requires less voter actions (in an ideal session) than a higher classification. Further improvements on the JLP may give another perspective on usability as well as using the established Systems Usability Scale as such scales are not designed specifically for eVoting machines. (Brooke et al., 1996)

Finally, the abstract nature of our interface features, abstracts away from the lower hardware level (in contrast to the EVCS developed by Franklin and colleagues). We believe that this abstraction ensures a more robust classification that is less easily affected by technology innovations in electronic voting user interface design.

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