Just Like Paper - a baseline for classifying e-voting usability

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Abstract: This work presents a feature-oriented taxonomy for commercial electronic voting machines, which focuses on usability aspects. We analyze the incremental differences in functionality – the features - between voting systems and how that functionality differs from 'traditional' pen and paper based voting. Based on this analysis, we propose a 'Just-Like-Paper' (JLP) classification method. We validated the JLP classification method to the ongoing development of our novel DualVote eVoting system, where its application led to the development of a passive feedback protocol which improved the usability features.

Keywords: ICT, Classification, eVoting, Usability

1. Introduction This paper is based on previous work on the Dual Vote system. (MacNamara et al., 2010), (MacNamara et al., 2011), (Gibson et al., 2011). It extends and completes the work that was previously reported as ongoing (MacNamara et al., 2013). The main novelty of Dual Vote is that a voter's preference is simultaneously recorded on both electronic and paper media. Whilst the user casts a vote using a pen and paper interface the system interface simultaneously records the vote electronically using an optical sensor array. This duality is made possible by a capacitive-based electronic pen whose operation is identical (from the users' point of view) to a traditional non-electronic pen. This novel user interface (UI) addresses the crucial issue of how to achieve both usability and verifiability, which is recognized as one of the most difficult challenges in the development of modern e-voting systems.

During the DualVote development process, we were interested in how functionality (features) could be added to the system– in an incremental fashion - without weakening our most fundamental requirement: that our system be just like the traditional pen and paper method of voting used in the Republic of Ireland. The need for high usability was central to the development of DualVote and its *raison d'être* was in providing a familar pen and paper (albeit electronic) interface to the voter. While we were able to demonstrate high usability for the system during various field studies, DualVote still only provided basic functionality. Voters could simultaneously cast their vote electronically and on paper but no feedback, confirmation or otherwise was given to the voter. . To help us understand how to improve our basic machine functionality we analysed twenty-six commercial eVoting systems primarily used in the United States and catgorised the systems in terms of their interface features and functionality. From the resulting JLP classification,

we understood that providing feedback was an important factor for instilling confidence in the system amongst the electorate. Adding a feedback feature – without compromising the JLP approach – is one of the main results reported in this paper.

Alternative classification models have been developed for eVoting schemes based on differing criteria, each providing a different focus. One such classification – which is close to the JLP classification - defines systems based on how the voter submits their vote to the tallying authority. Systems are then classified as: Hidden voter (anonymous voter) hidden vote (encrypted vote), hidden voter with hidden vote. (Sampigethaya et al., 2006). However, such classifications abstract away from usability issues. 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 four-layer classification structure: 1)Core technology, 2) components, 3) voter interface and 4) ballot presentation; and it is termed the Electronic Voting Classification Structure (EVCS). The motivation for the work was to create a 'universal 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).. The EVCS is very different from the JLP classification system: EVCS is very broad, examining a very wide range of criteria, but JLP is quite narrow, focusing on usability aspects and interface design.

Our motivation for this work was two–fold: Firstly, to examine how to apply additional functionality to our system without weaking our 'just-like-paper' requirement and secondly, to develop a straightforward numeric classification for commercial eVoting systems which could ultimately be reused by evoting system developers and procurers. As we were developing a commercial eVoting system with a novel user interface, the JLP classification examines systems in terms of both interface features and the design decisions that implement those features. Section 2 describes the JLP classification, Section 3 defines the system interface features and categorises each system in terms of its similarity to our pen and paper baseline, Section 4 outlines the particular design decisions relating to each interface feature, Section 5 presents a discussion and conclusion.

2. JLP Classification

The JLP classification arises from a feature-oriented analysis of e-voting interface design and usability requirements. 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, completely non-electronic, 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. (We chose this baseline as this was the system that Dual Vote was hoping to be able to replace, or demonstrate its superiority against). Ultimately, our goal is to develop our DualVote system to the extent where the usability of pen and paper –as demonstrated in the baseline - is preserved while having some of the extended functionality of electronic voting. The JLP classification thus starts with systems which are closest to our baseline. To rank the systems, we use the postfix JSN (JLP System Number) followed by the appropriate ranking. 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. For each system, our classification employs the following steps: (i) Specification of Interface Features and (ii) Specification of Design Decisions.

3. Specification of Interface Features

The first step in our classification was to analyze the commercial eVoting systems in terms of their 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, the ES&S Accuvote[1] 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, the ES&S Inkavote[2] 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.** We define a dedicated activation interface as an interface that the voter interacts with for the sole purpose of activating the voting machine. The voter will not perform any other task on this interface. For example, on optical scan voting systems such as the HART eScan[3], the machine is activated when the voter inserts a ballot into the optical scanner. On other systems such as the MicroVote Infinity[4] 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. On the HART eScan, the optical scanner also processes the vote and is therefore not 'dedicated' to machine activation.

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1 US Department of State. (n.d.). *ACCU VOTE Voting Equipment for Jackson County*. Retrieved 1 9, 2012, from Department of State: http://www.michigan.gov/sos/0,1607,7-127-1633_8716_45458-163260--,00.html

2 Los Angeles County. (n.d.). *Registrar Recorder/County Clerk InkaVote Video Demo*. Retrieved 1 9, 2012, from Los Angeles County : http://www.lavote.net/Voter/VIDEOS/Default.cfm?VideoID=3

3 HART Intercivic. (n.d.). *How To Vote*. Retrieved 1 12, 2012, from HART Intercivic Company Website: http://www.hartic.com/pages/360

4 MicroVote General Corporation. (n.d.). *Microvote Corporatio*. Retrieved 1 10, 2012, from Home Page: http://www.microvote.com/products.htm

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 (SEAS 4000[5], ELECTronic 1242[6] and the iVOTRONIC[7]) are 'multi-modal' requiring the voter to interact with more than one interface– for example selecting candidates on a push-button interface while confirming them on a touch-screen. 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 (eSlate), Vote-recorder apparatus (InkaVote), Pen-stylus for touch screen (Populex[8]).

From our review of the eVoting systems we found fourteen distinct interface features of eVoting interfaces which fall under the various five broad categories. We use the prefix 'IF' followed by a number to index the interface features.

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;

5   Smartmatic Inc. (n.d.). *How To Vote*. Retrieved 1 10, 2012, from Smartmatic Corporate Home: http://www.smartmatic.com/fileadmin/users/videos/Boton.wmv

6   State of Delaware. (n.d.). *How To Use Delaware's Voting Machine*. Retrieved 1 15, 2012, from State of Delaware: http://electionsncc.delaware.gov/use_vm/index.shtml

7   Jefferson County. (n.d.). *Jefferson County*. Retrieved 1 10, 2012, from Jefferson County iVotronic Demo: http://www.jeffersoncountypa.com/ivotronic.htm

8   Populex. (n.d.). *Populex Digital Paper Ballot System Voting Process*. Retrieved 01 15, 2012, from Populex Digital Paper Ballot System: http://www.populex.com/DPB_Voting.htm

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.

Ordering of features

Features within each category are ordered in terms of their commonality with our baseline. Our baseline does not have any error feedback, ballot confirmation, activation interface or duality generation features. Furthermore the vote creation interface is uni-modal. The ordering of interface features is described as follows:

Error Feedback. Our baseline has no error-feedback interface features. The next functionality increment is 'basic' error feedback, offering some feedback functionality. This is followed by the 'detailed' feedback, which offers more functionality than both 'basic feedback' and 'no feedback'.

Ballot Confirmation. Our baseline has no ballot confirmation. The next functionality increment is 'some confirmation' (in the case of a detected error) followed by 'always confirmation' where the voter must always confirm their vote.

Activation. This is a binary choice between 'voter activated' and 'not voter activated'. The ordering is therefore straightforward.

Duality Generation. Our baseline has no simultaneous vote generation features. The next functionality increment is simultaneous duality generation - where the voter can generate both an electronic and paper vote with one action. This is followed by duality generation with multiple voter actions.

Interface Modality. Our baseline is uni-modal offering one vote creation interface. The next functionality increment is multi-modal offering two vote creation interfaces followed by systems offering non-standard interfaces.

Because the baseline offers little in terms of functionality, the ordering of the features can also give an indication of the functionality and interface modality of the system. The features are ordered in terms of functionality - no functionality, some functionality and full functionality. For interface modality, the ordering is in terms of modality (one interface, two or more interfaces, non-standard interface). The ordering of the features in this way also allows us to further differentiate between systems. In Figure 1, we show the first twenty-five classifications. If a classification of machine contains a particular feature, that feature column contains a '1' otherwise it contains a '0'. Our baseline is first in the list and is numbered JSN1. In total there are one-hundred and sixty-two possible classifications. We calculated this figure by documenting every possible combination of features. The entire list is not presented here for readability purposes. In addition, not all of the possible classifications are mapped to a commercial system.

IF14	IF13	IF12	IF11	IF10	IF9	IF8	IF7	IF6	IF5	IF4	IF3	IF2	IF1	Common Feat.	Diff. Mag	Classification
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	1	0	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 Mapping of Commercial Systems to Interface-Features

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. As an example, Figure 2.0 shows the JLP Table entry for the ES&S Accuvote (JSN22).

	IF14	IF13	IF12	IF11	IF10	IF9	IF8	IF7	IF6	IF5	IF4	IF3	IF2	IF1
ES&S AccuVote-OS with Ballot Box	0	0	1	1	0	0	0	1	0	0	1	0	1	0

Figure 2 ES&S Accuvote JLP Table Entry

From the table, we see that the system has three features in common with our baseline (IF4, IF7 and IF12). Therefore the Common Features equal to three. The Difference Magnitude is calculated by subtracting the unmapped feature number from the corresponding baseline feature number. For the ES&S Accuvote, this is (IF2-IF1) which is equal to 2-1, which is 1 and then (IF11-IF9) which is equal to 11-9, which is 2. We then add the 1 and 2 together to get a difference magnitude of 3. Because the features are ordered in terms of functionality, a higher difference magnitude represents higher functionality or a more complex modality and subsequent difference to pen and paper.

4. Specification of Design Decisions

To get a better understanding of how the differences in functionality or modality are implemented across the systems, we categorized what we term 'design decisions'. A design decision represents the selection of a particular hardware or software option and determines how the interface feature is implemented The specification also allows us to separate the abstract interface features from specific hardware, allowing the classification more robustness with regards to future technological developments.

D_X_0: Feature not installed / applicable;

Decisions relating Voter Feedback Features:

D_F_1: The voter receives feedback via an electronic visual display;
D_F_2: The voter receives feedback via an optical scanner / optical scanner information panel;
D_F_3: The voter receives feedback via a push-button interface;
D_F_4: The voter receives feedback via a printed receipt.

Decisions relating to Vote Confirmation Features:

D_C_1: The voter confirms their vote using a touch-screen;
D_C_2: The voter confirms their vote using a push-button;
D_C_3: The voter confirms their vote on the optical scanner / optical scanner information panel.
D_C_4: The voter confirms their vote using a pen with an attached push-button;

Decisions relating to Machine Activation Features:

D_A_1: The voter machine activates using an activation token;
D_A_2: The voting machine activates using the ballot paper;
D_A_3: The voting machine activates using a poll worker interface or is permanently activated;

Decisions relating to Duality Generation Features:

D_P_1: The paper audit trail interface consists of a ballot box;
D_P_2: The paper audit trail interface consists of a printer;

D_P_3: The paper audit trail interface consists of a printer and ballot box;

D_P_4: The paper audit trail consists of an optical scanner with attached ballot box;

Decisions relating to Interface Modality Features :

D_I_1: The vote creation interface consists of a touch-screen;

D_I_2: The vote creation interface consists of a push-button

D_I_3: The vote creation interface consists of a pen and paper;

D_I_4: The vote creation interface consists of a touch-screen and push-button

D_I_6: The vote creation interface consists of a push-button and pen and paper;

D_I_7: The vote creation interface consists of a pen and paper and non-standard technology;

D_I_8: The vote creation interface consists of a touch-screen and non-standard technology;

D_I_9: The vote creation interface consists of a push-button and non-standard technology.

D_I_10: The vote creation interface consists of a hybrid electronic pen and paper.

From our analysis of the eVoting systems we discovered twenty-five distinct design decisions which allow for the interface features to be implemented. The decisions are split into six categories represented by the prefix D and followed by the category prefix. We feel that this list can continue to expand with developments in technology without adversely affecting the classification.

5. Discussion and Conclusion

5.1 Discussion

From our analysis of the twenty-six commercial systems, we found that these mapped to fifteen distinct classifications which are shown in Figure 3.0. We first looked at the lowest and highest classification numbers to get an understanding of the extremities of current commercial systems. The lowest classified system is the Bhorat Electronics EVM[9], (JSN2) which originated in India. This is a rudimentary eVoting system which offers little in terms of functionality. It is the baseline in terms of electronic eVoting machines, offering only basic feedback to the voter via a push-button LED panel (D_F_3). The system with the highest classification is the HART eSlate which has nothing at all in common with our baseline in terms of functionality or modality. It features detailed feedback, compulsory confirmation, machine activation, duality with multiple actions and a non-standard vote creation interface implemented by a navigation wheel (D_I_9).

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9   Chief Electoral Officer Delhi. (n.d.). *A Guide For Voters*. Retrieved 1 10, 2012, from Cheif Electoral Officer Delhi: http://ceodelhi.gov.in/WriteReadData/Voters/A%20guide%20for%20voters.pdf

Figure 3 Commercial Systems within the JLP Table

	IF14	IF13	IF12	IF11	IF10	IF9	IF8	IF7	IF6	IF5	IF4	IF3	IF2	IF1	Classification
Bhorat Electronics EVM	0	0	1	0	0	1	0	1	0	0	1	0	1	0	JSN2
Dual Vote-3	0	0	1	0	1	0	0	1	0	0	1	0	0	1	JSN5
Anotto Pen Vote	0	0	1	0	1	0	0	1	1	0	0	0	0	1	JSN21
ES&S AccuVote-OS with Ballot Box	0	0	1	1	0	0	0	1	0	0	1	0	1	0	JSN22
Unilect Patriot	0	0	1	0	0	1	0	1	1	0	0	1	0	0	JSN25
WINVOTE	0	0	1	0	0	1	0	1	1	0	0	1	0	0	JSN25
Nedap ES3B	0	0	1	0	0	1	0	1	1	0	0	1	0	0	JSN25
Software Improvements eVACS	0	0	1	0	0	1	1	0	1	0	0	1	0	0	JSN41
MicroVote Infinity Voting Terminal	0	0	1	0	0	1	1	0	1	0	0	1	0	0	JSN41
Unisyn OpenElect OVO	0	0	1	1	0	0	0	1	0	1	0	1	0	0	JSN42
Sequoia Insight	0	0	1	1	0	0	0	1	0	1	0	1	0	0	JSN42
ES&S DS200	0	0	1	1	0	0	0	1	0	1	0	1	0	0	JSN42
Dominion ImageCast Tabulation	0	0	1	1	0	0	0	1	0	1	0	1	0	0	JSN42
Hart eScan	0	0	1	1	0	0	0	1	0	1	0	1	0	0	JSN42
ES&S M100	0	0	1	1	0	0	0	1	0	1	0	1	0	0	JSN42
VOTEX Electronic Voting System	0	0	1	1	0	0	0	1	1	0	0	1	0	0	JSN46
Unisys Diebold UE96-06 VVPAT	0	0	1	1	0	0	1	0	1	0	0	1	0	0	JSN54
ES&S AccuVote-TSX	0	0	1	1	0	0	1	0	1	0	0	1	0	0	JSN54
Scytl.Pnyx.VVPAT	0	0	1	1	0	0	1	0	1	0	0	1	0	0	JSN54
Indra Print and Vote with Printer	0	0	1	1	0	0	1	0	1	0	0	1	0	0	JSN54
Sequoia AVC Edge	0	0	1	1	0	0	1	0	1	0	0	1	0	0	JSN54
ELECTronic 1242	0	1	0	0	0	1	0	1	1	0	0	1	0	0	JSN78
ES&S iVotronic	0	1	0	0	0	1	1	0	1	0	0	1	0	0	JSN95
Smartmatic SAES 4000	0	1	0	1	0	0	0	1	1	0	0	1	0	0	JSN100
ES&S/Unisyn Inkavote Plus	1	0	0	1	0	0	0	1	0	1	0	1	0	0	JSN150
Populex Digitial Paper Ballot	1	0	0	1	0	0	0	1	1	0	0	1	0	0	JSN154
Hart eSlate	1	0	0	1	0	0	1	0	1	0	0	1	0	0	JSN162

The basic functionality of the Bhorat EVM appealed to us as it gave the voter at least some feedback that their vote was correctly interpreted. Although the EVM's basic feedback was passive, the LED did not give rise to the spoiled/unspoiled nature of the vote. We knew that to implement basic feedback with a spoiled/unspoiled indicator, we needed to use additional LEDs. The HART eSlate was on the opposite end of the spectrum, and interestingly it mapped to the highest possible classification – JSN162. Unlike the EVM, the eSlate offered detailed feedback via an LCD screen (D_F_1). We could also consider detailed feedback which was passive in nature for the DualVote machine but we didn't want to introduce an LCD as we believed it may complicate the voting process. With regards to other functionality, the Bhorat EVM had nothing to suggest, however the HART eSlate included confirmation of the vote via D_C_2, activation of the machine via D_A_1, in terms of duality generation it offered nothing new over DualVote as multiple user actions were required in order to vote (unlike the simultaneous generation of DualVote). Finally, the eSlate had a non-standard interface (D_I_9). Neither D_C_2, D_A_1 or D_I_9 were appealing to us as they all weakened our 'just like paper requirement'. As expected, nothing could be taken in terms of interface features from a commercial system that was in essence 'least like paper'.

Our next step in our efforts to expand the functionality of DualVote was to find some middle-ground between JSN2 and JSN162. We next looked at JSN21 which was the only other digital/hybrid pen-based voting system on the list. In the Clackmannanshire trail election of 2006, the Anotto[10] pen provided confirmation to the voters via a push-button interface (D_C_4) on the pen itself. We knew from a subsequent report from Clackmannanshire Town Council that most

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10   □Anoto. (2007, November 23). *Archives.* Retrieved from Anoto: http://www.anoto.com

voters forgot to push the button after voting[11]. No other functionality was offered on this particular Anotto-pen system.

We had an intuition at this stage that without introducing a full LCD screen to provide voter feedback – detailed feedback would weaken our most fundamental requirement beyond what was acceptable to us. We began to look at other classifications which offered basic feedback, namely – JSN22, the ES&S Accuvote with ballot box. The obvious problem here of course was the Accuvote was an optical scan system that gave binary feedback via D_F_2. The ballot was either accepted or rejected by the scanner. This was not applicable to the passive scanning nature of DualVote.

Regarding vote confirmation, we knew from our analysis that this would require the addition of an LCD screen (or at the very least the implementation of D_C_4 which did not appear successful to date). We came to the conclusion that more in-house usability testing could give a clearer indication of how this would work for DualVote.

Finally, machine activation, duality generation and interface modality were an easy call. Considering that DualVote had a high usability score with little extended functionality (in particular vote confirmation and feedback), implementing activation or a multi-modal interface would likely lessen the usability score without providing extra functionality. As far as we were concerned, DualVote already offered simultaneous duality generation which we considered advantageous as it (ideally) required less user actions and there was no current scope of improvement in this regard.

We did however extend the functionality of DualVote to include passive voter feedback via a three-color LED panel, we have reported extensively on this protocol in other work (Gibson et al., 2011).

5.1 Conclusion

The JLP classification shows how twenty-six commercial systems incrementally differ from each other in terms of functionality and subsequently how each system differs from our baseline. Naturally, this list of commercial systems is not intended to represent every commercial eVoting system, but it is presented as a representation of the most common systems found in use at the time of writing. Whereas many other commercial and experimental systems exist, it was beyond the constraints of this work to facilitate each design into this classification. The JLP facilitated understanding of 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. Analysis showed our system lacking feedback and confirmation features, but rich 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. We have shown that this classification can also be applied to usability. As future work, it would 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 feasible to deduce that an optimal interface would minimize the number of voter actions. However, this needs further exploration as different actions have different degrees of complexity, and different voters may have profiles more suited to some types of actions rather than others. In particular, our DualVote feedback mechanism has shown that there is a significant difference between active and passive verification.. Further improvements on the JLP may give another perspective on usability - the well-established Systems Usability Scale may be shown to be too generic. In cases, like e-voting machines, it may be better to uses a scale that is specific to the problem.(Brooke et al., 1996)

It should be noted that the abstract nature of our interface features, hides the lower hardware level (in contrast to the EVCS developed by Franklin and colleagues). We believe that this abstraction is

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11 Clackmannanshire Council (2006). Retrieved from: http://www.clacksweb.org.uk/council/press/?release=933#

a more robust classification that is less likely to become obsolete due to the fast moving technological innovation in electronic voting system and user interface design.

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