Enhanced Secure Interface for a Portable E-Voting Terminal

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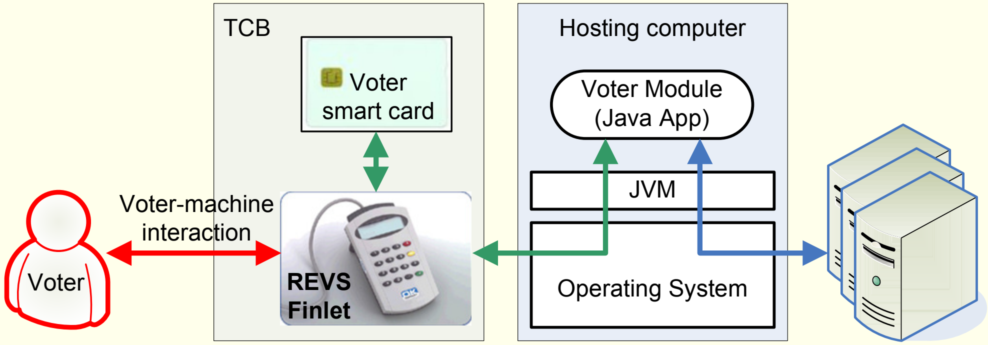
Context:

E-voting mobility

- One advantage of e-voting is the “voting anywhere” paradigm
  - Possibly using untrusted computers (e.g. cyber-caffes)



- Portable, personal TCB for the REVS e-voting system [WRAITS07]
  - Smart card and FINREAD terminal with human I/O interface
  - May be used with any host computer
    - Hosts provide Internet access to REVS electoral servers
    - A voter interacts only with his TCB

Problem:

FINREAD terminal limitations

- Used to securely present questions & answers to the voter
  - Ballot questions (for correctness)
  - Answers (for secrecy)
- FINREAD output display is small
  - Only 4 lines of 80 characters
- Global ballot view is an issue
  - With long ballots
  - With many answers per question

Objective

- Enhance the output capabilities of the TCB without compromising voters' security
  - Voters' answers must remain secret to the TCB
  - Ballot questions must be correctly presented to voters

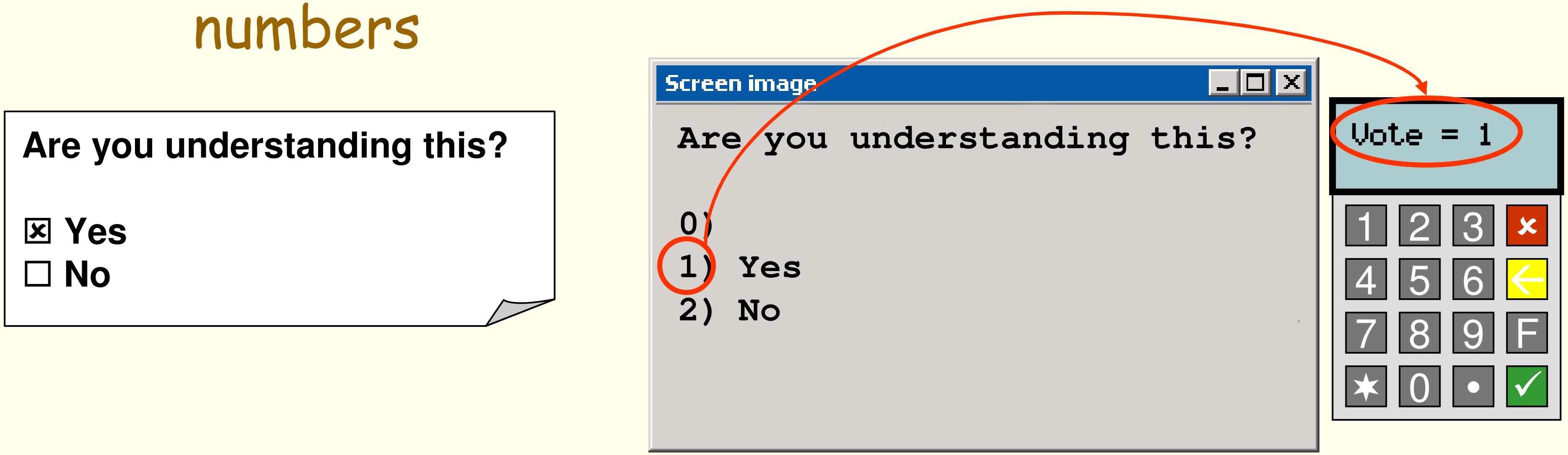
Contribution:

Enhanced, secure TCB interface

- Secure cooperation with hosting computers
  - The hosting computer presents an image of the ballot to the voter
    - Enhanced interface, global view of the ballot
  - The image should not disclose voter's choices
    - Secrecy / privacy
  - The image should allow the voter to detect relevant modifications introduced by the hosting computer
    - Correctness (of Q&A)

Non-disclosure of voters' choices

- The image presented by the hosting computer does not contain voter's choices
  - They are presented at the FINREAD display
  - Possible answers and choices are linked by numbers



Are you understanding this?

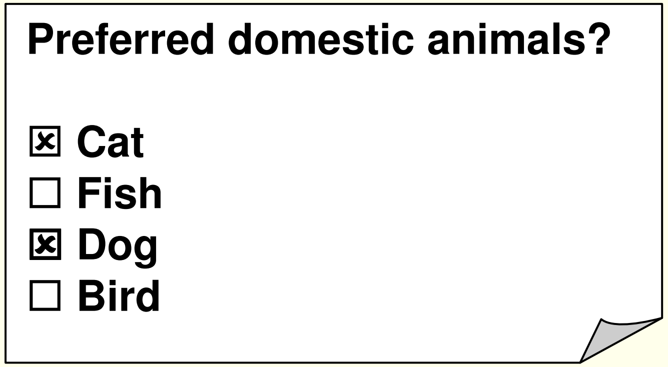
☒ Yes
☐ No

Screen image

```
Are you understanding this?

0)
1) Yes
2) No
```

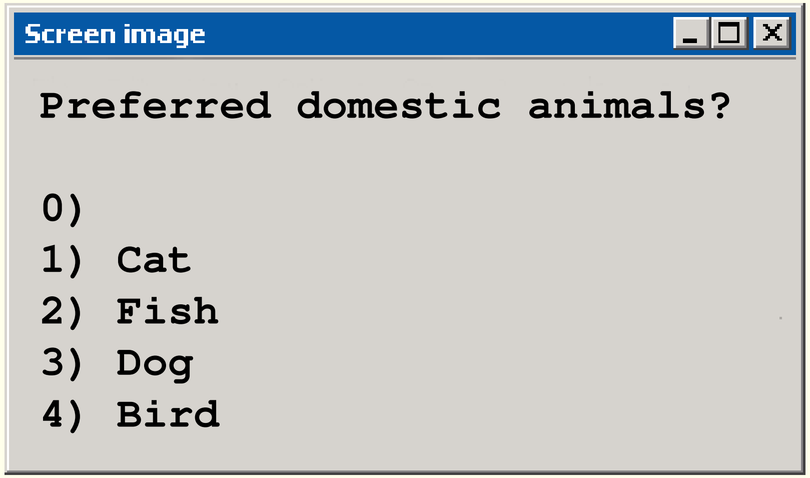
Vote = 1

Non-disclosure of voters' choices: Expressing multiple votes

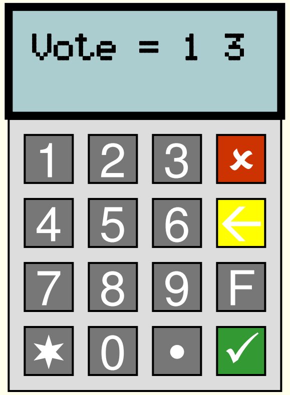


Preferred domestic animals?

- ☒ **Cat**
- ☐ **Fish**
- ☒ **Dog**
- ☐ **Bird**



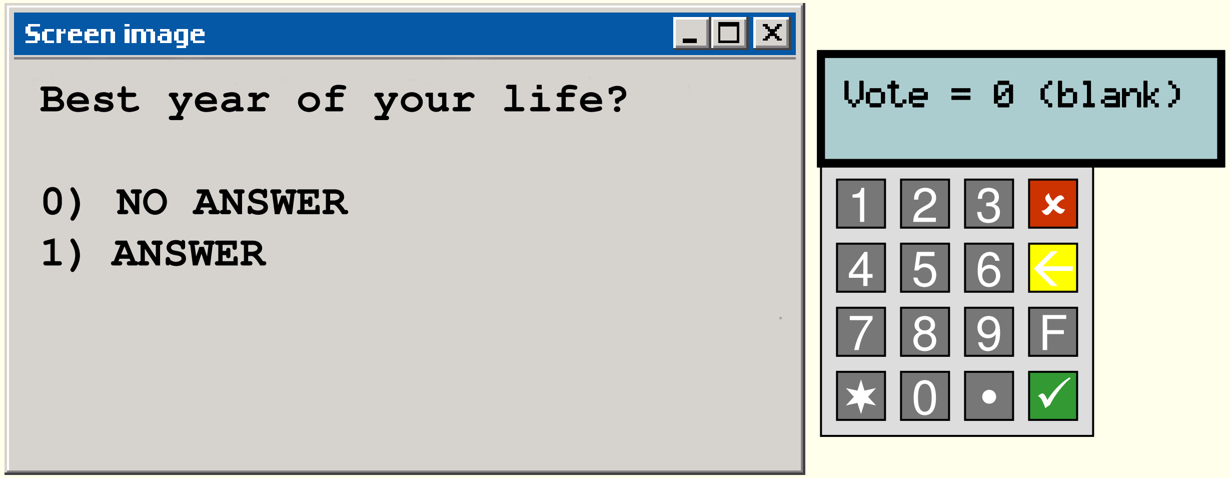
```
Preferred domestic animals?

0)
1)  Cat
2)  Fish
3)  Dog
4)  Bird
```



Vote = 1 3

Non-disclosure of voters' choices: Expressing values in ranges

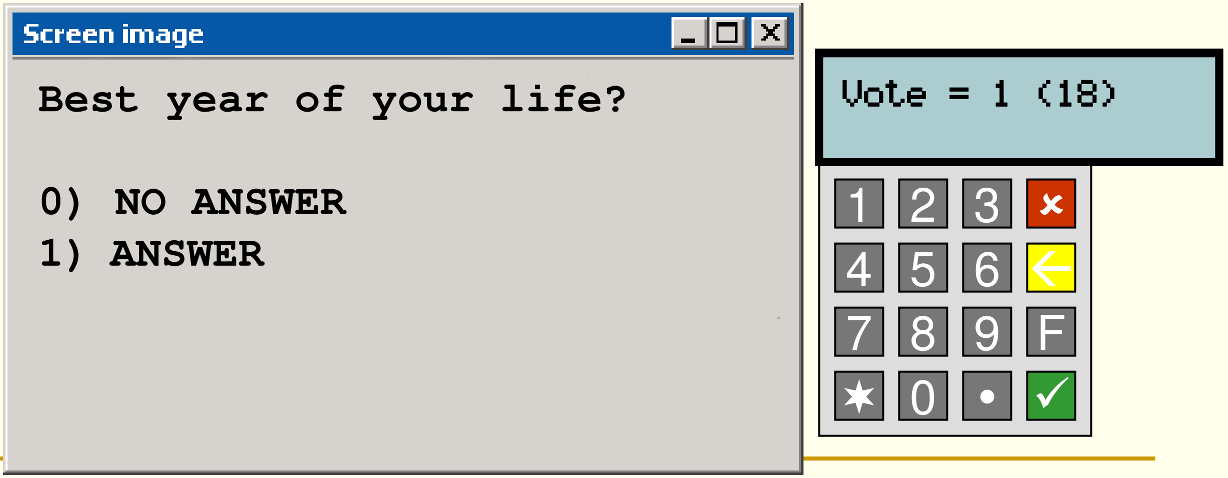
Best year of your life? ___



```
Best year of your life?

0)  NO ANSWER
1)  ANSWER
```

Vote = 0 (blank)

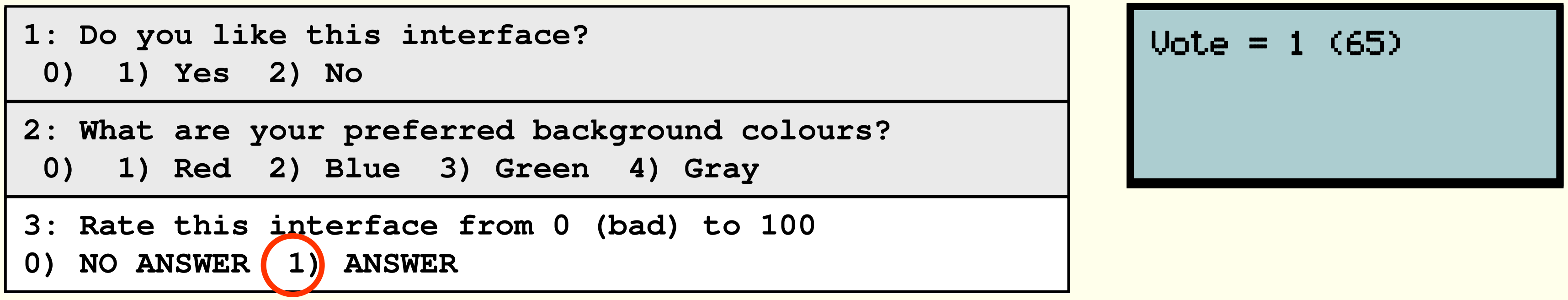
Best year of your life? 18



```
Best year of your life?

0)  NO ANSWER
1)  ANSWER
```

Vote = 1 (18)

Ballot browsing for filling/checking Q&A



```
1: Do you like this interface?
 0)   1) Yes   2) No
```

```
2: What are your preferred background colours?
 0)   1) Red   2) Blue   3) Green   4) Gray
```

```
3: Rate this interface from 0 (bad) to 100
0) NO ANSWER [✓ 1) ANSWER]
```

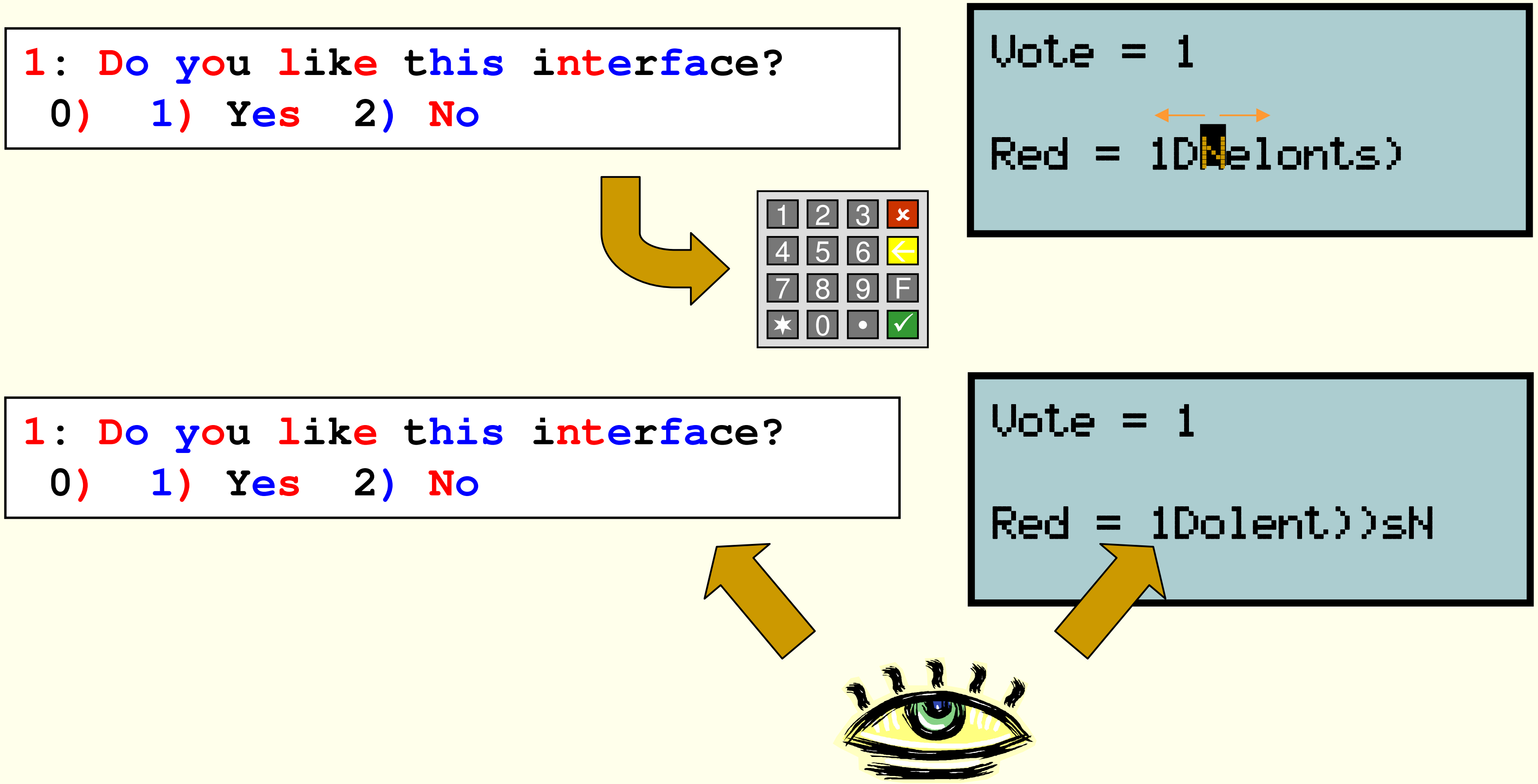
```
Vote = 1 (65)
```

Authentication of ballot images

- Ballot images must be visually authenticated by voters
  - To prevent hosting computers from changing the ballot
- Authentication with feedback
  - The ballot is displayed with some highlighted details
  - The voter checks them details with the FINREAD terminal
  - Active feedback
    - The voter inputs the highlighted details in the FINREAD terminal
    - The FINREAD produces an OK/NOK authentication result
  - Passive feedback
    - The FINREAD terminal presents the highlighted details
    - The voter visually checks the match
- We chose colours for highlighting feedback characters

Feedback with colours:

Examples of active / passive feedback



1: Do you like this interface?
 0) 1) Yes 2) No

Vote = 1

Red = 1DNelonts)

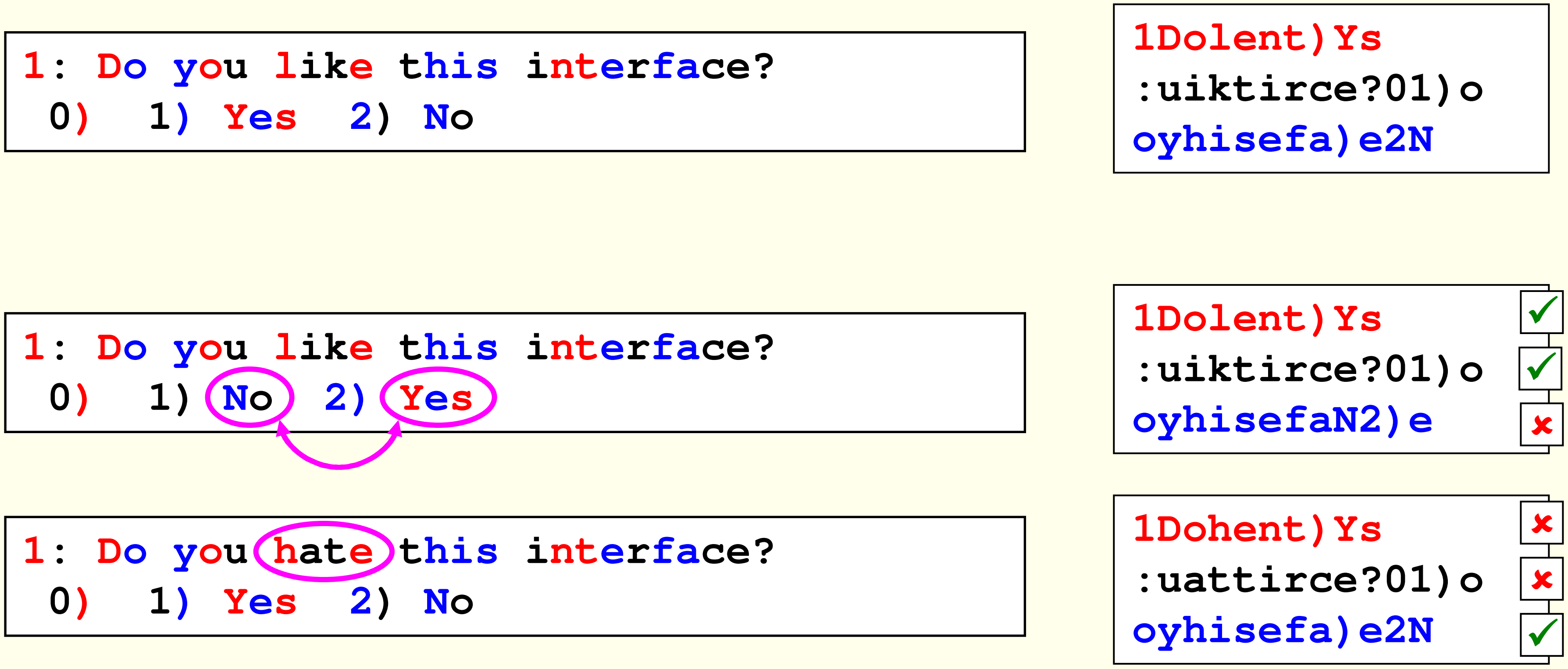
1: Do you like this interface?
 0) 1) Yes 2) No

Vote = 1

Red = 1Dolent))sN

Feedback with colours:

Undetectable tampering is possible



```
1: Do you like this interface?
 0)   1) Yes   2) No
```

```
1Dolent)Ys
:uiktirce?01)o
oyhisefa)e2N
```

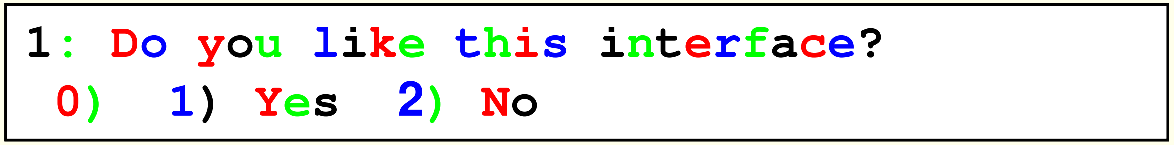
```
1: Do you like this interface?
 0)   1) No   2) Yes
```

```
1Dolent)Ys       ✓
:uiktirce?01)o   ✓
oyhisefaN2)e     ✗
```

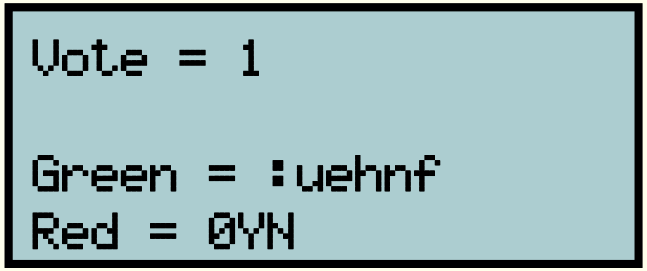
```
1: Do you hate this interface?
 0)   1) Yes   2) No
```

```
1Dohent)Ys       ✗
:uattirce?01)o   ✗
oyhisefa)e2N     ✓
```

Feedback with colours: Reduction of tampering success probability



```
1: Do you like this interface?
 0)   1) Yes   2) No
```



```
Vote = 1

Green = :uehnf
Red = 0YN
```

- Solution adopted for N feedback colours
  - Feedback is given with 2 colours (out of N)
    - One for the question, one for the answer
    - Possibly equal
  - Text is divided in blocks of N characters
    - All N colours are randomly used in each block
  - Voter can shuffle colours in the FINREAD terminal
    - Without changing the presented image

Security & usability analysis (1/2)

- Voter privacy
  - Displayed images do not convey personal choices
  - Voter privacy is kept
- Image authentication
  - Colour handling is an issue
    - More colours, more security, less usability
    - More feedback colours, more security, less usability
  - Compromise
    - Less possible number of colours, 2 feedback strings
    - Tampering is possible
      - But the success probability is low
      - It can be arbitrarily reduced with feedback shuffling

Security & usability analysis (2/2)

- Feedback validation
  - Passive validation is more convenient
    - But more prone to human errors
    - Careless voters may be deceived
    - Voters have to do error management
  - Active feedback is less convenient
    - But it becomes very hard to deceived voters
    - FINREAD terminal can do some error management

Preliminary usability experiences

- A prototype demonstrator was developed
  - Java applet
  - Passive feedback, adjustable colour palette
- Usability: lessons learned
  - Extensive colour scattering reduces readability
    - Solution: aggregation
    - Aggregates of characters with the same colour instead of single characters
  - Long questions/answers require many colours
    - For producing short feedback strings in the FINREAD
    - Visual colour separation becomes a problem
  - Colour blind people have natural difficulties
    - Personal tuning of the colour palette may help them

Conclusions

- The secure, enhanced interface relies on two different displays
  - One protected (FINREAD terminal)
    - Shows small amounts of information (choices & feedback strings)
  - One insecure (hosting computer display)
    - Shows an image of the ballot
- Visual authentication of ballots with colours
  - Randomly coloured feedback characters
  - Feedback strings may be shuffled
    - For improving confidence in the authentication
- Colour-based authentication is not trivial for voters
  - Unusual task
    - High cognitive workload
    - Usability tests must be performed to evaluate it
  - Training / personal tuning may reduce the cognitive workload