Adaptively Secure Broadcast

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ETH Zurich

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Outline

Talk Outline

- Motivation
- Known Broadcast Protocols
- Our Broadcast Protocols
- Conclusions

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Intuition

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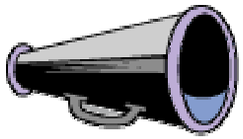

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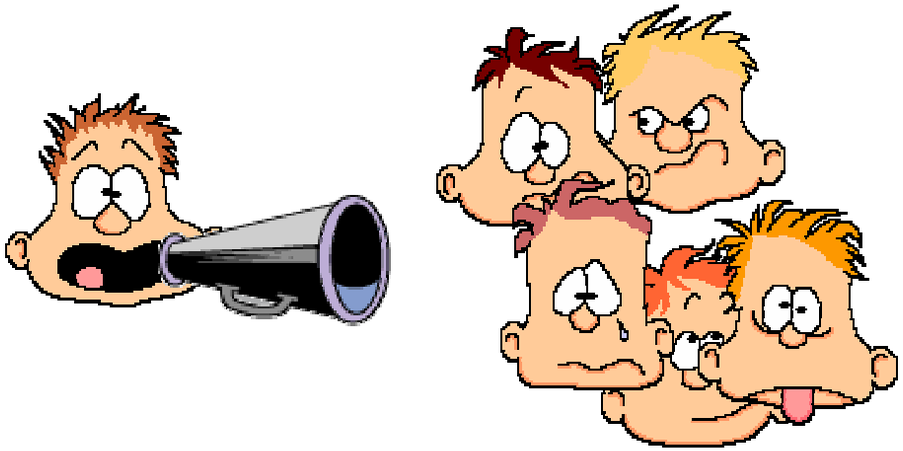

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- Property-Based Definition $\overset{?}{\approx}$ Megaphone

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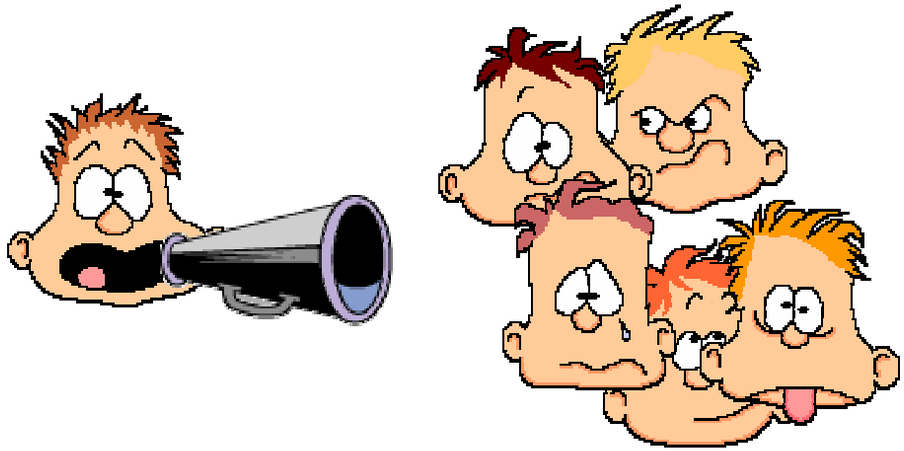
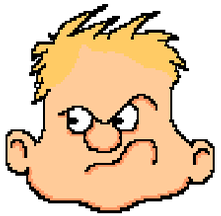
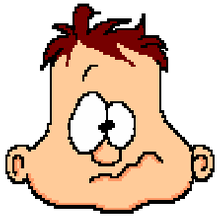
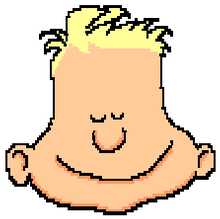


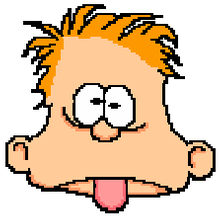
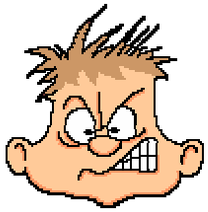
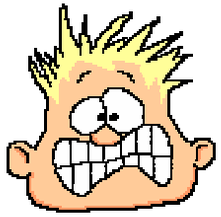
This Work

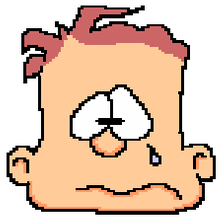
Contributions

1. Property-based definition of broadcast $\not\approx$ megaphone
2. Known broadcast protocols $\not\approx$ megaphone
3. Construct megaphone protocol (perfect / stat. / crypto.)

An Example

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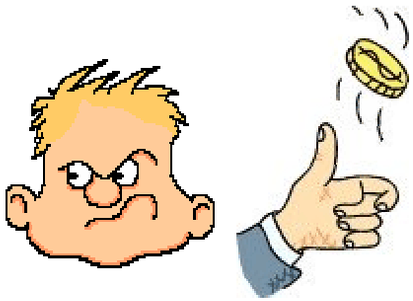

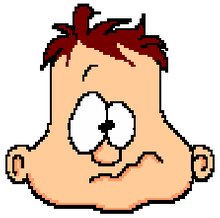

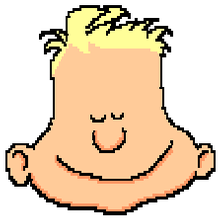

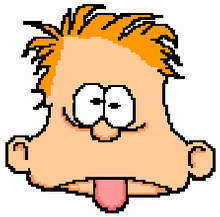

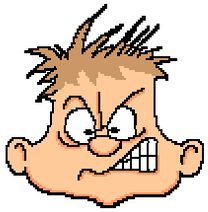

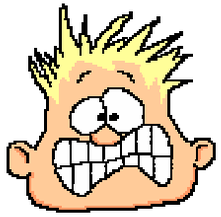

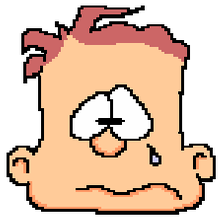

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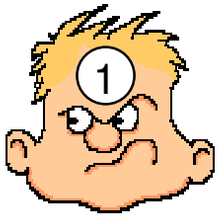

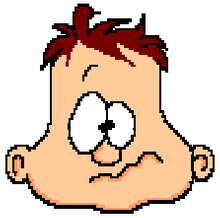

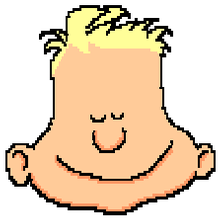

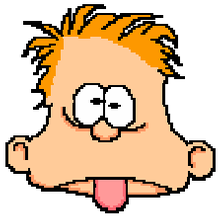

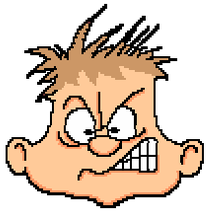

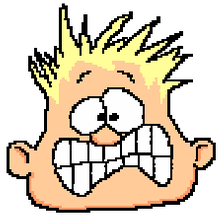

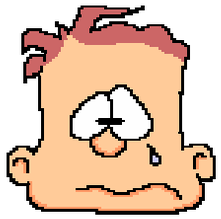

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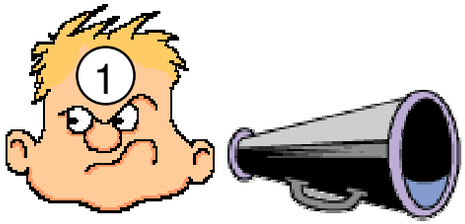

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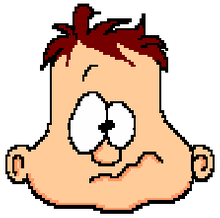

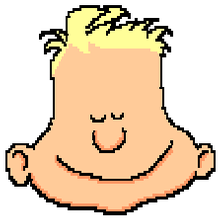

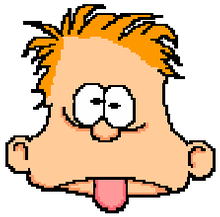

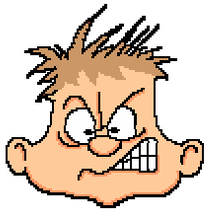

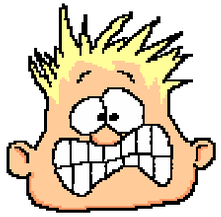

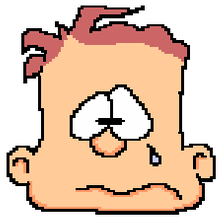

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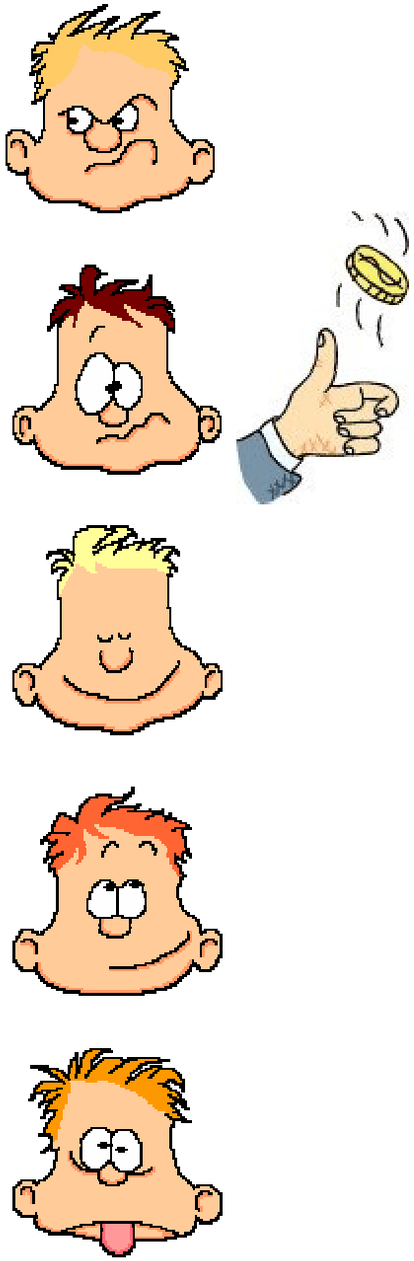

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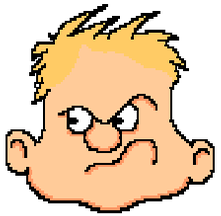

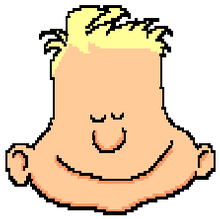

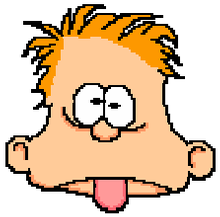

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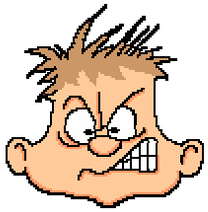

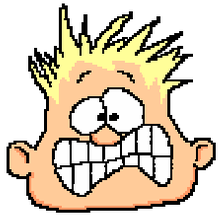

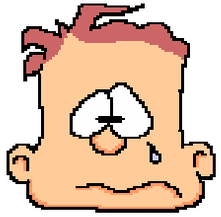

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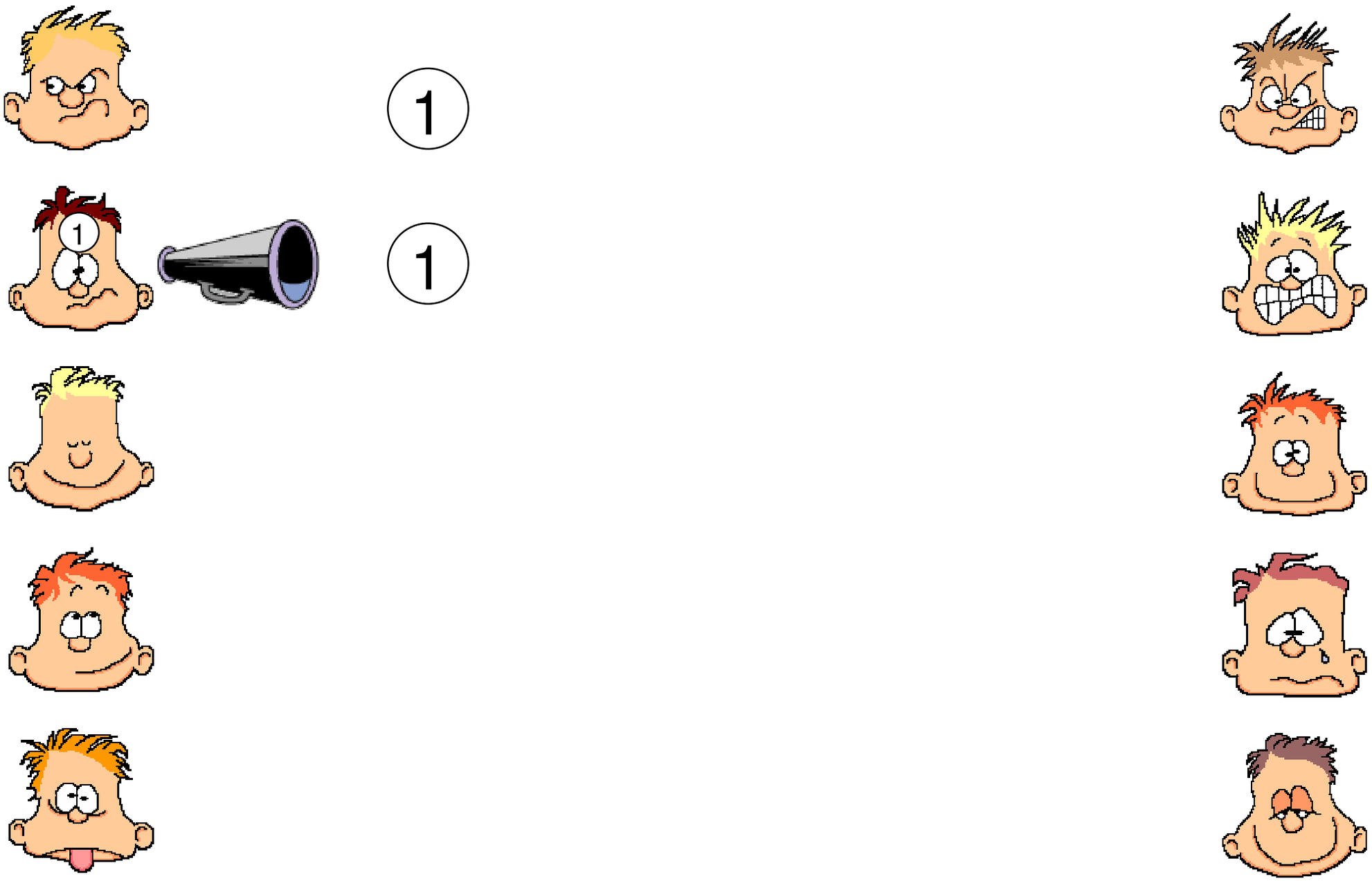

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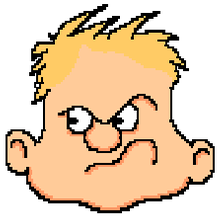

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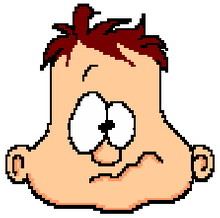

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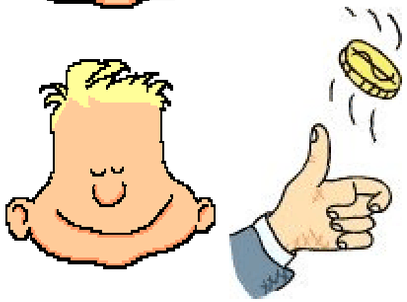

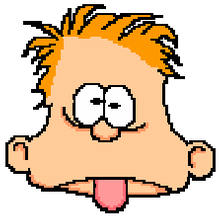

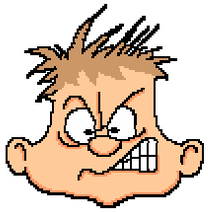

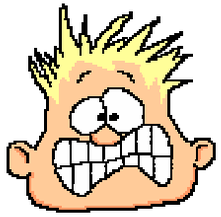

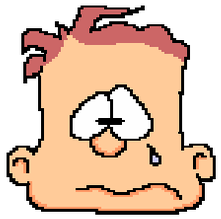

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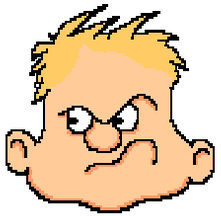

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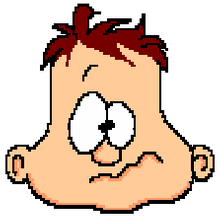

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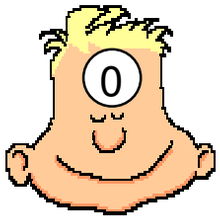

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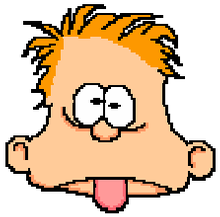

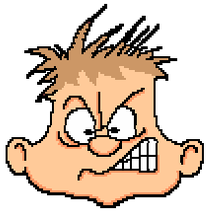

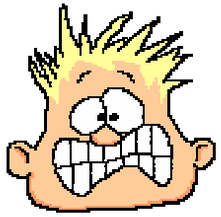

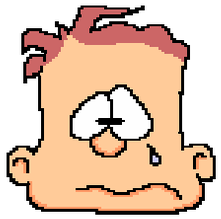

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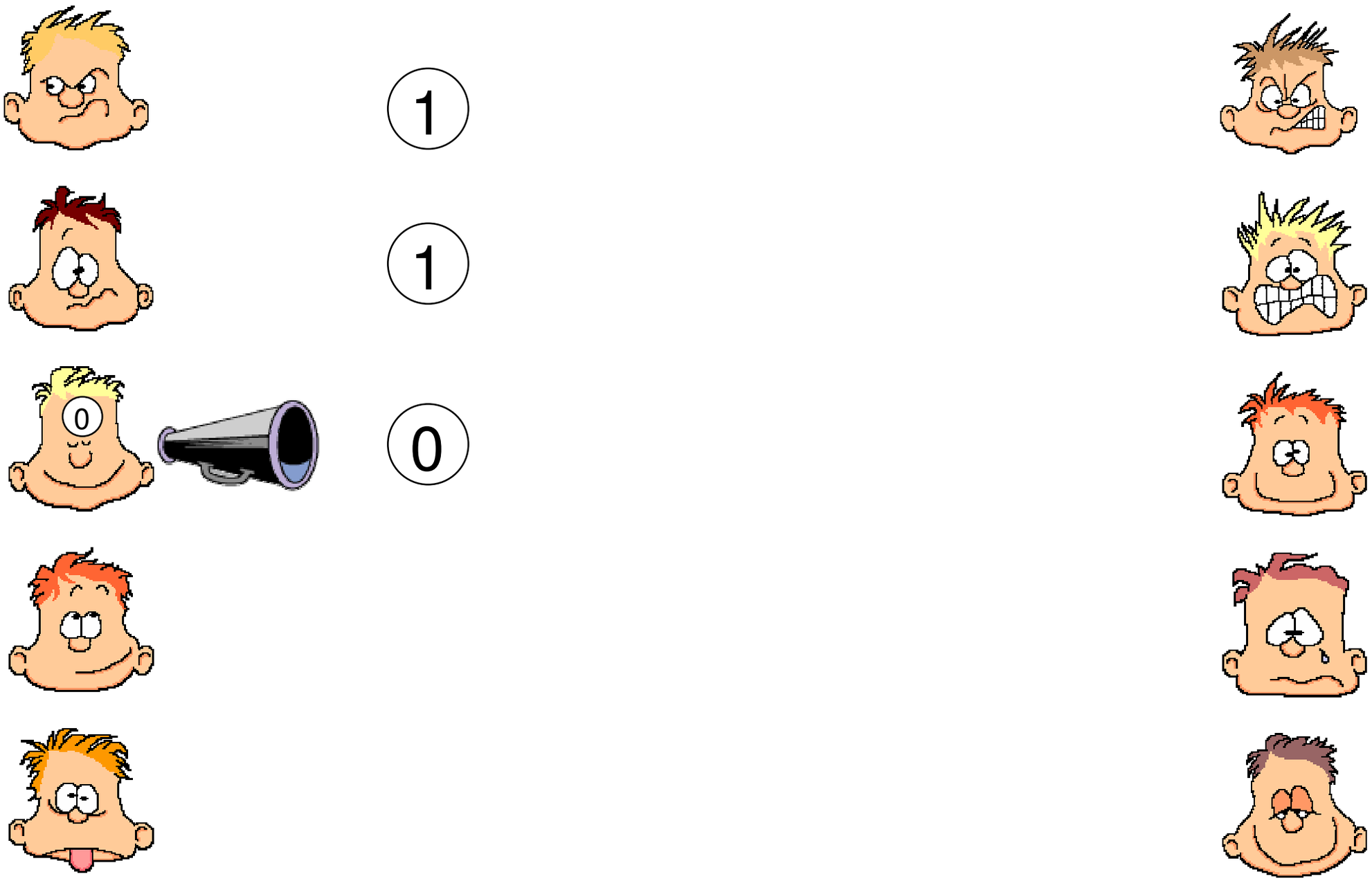

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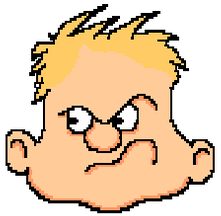

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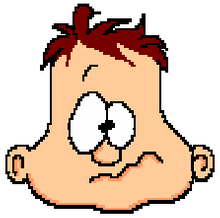

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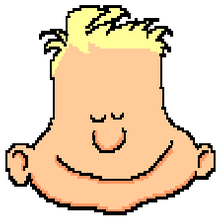

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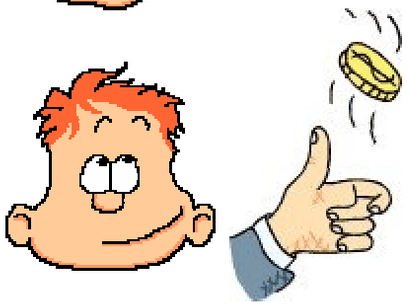

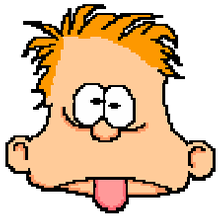

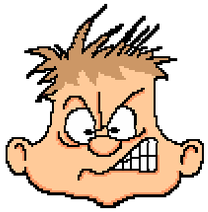

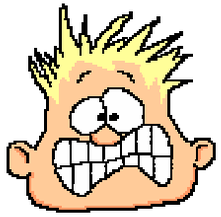

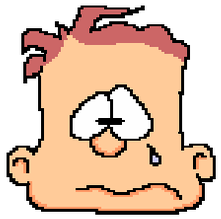

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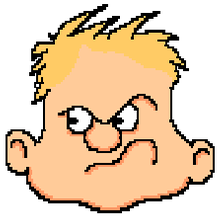

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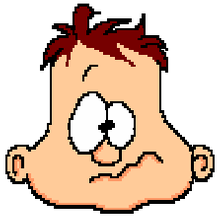

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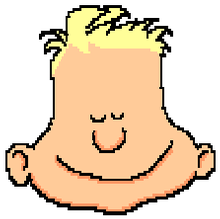

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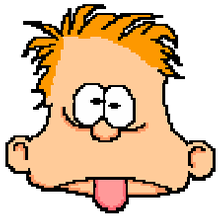

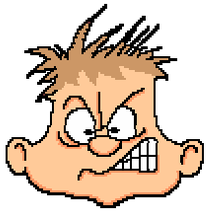

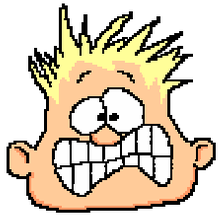

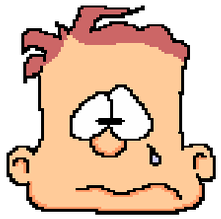

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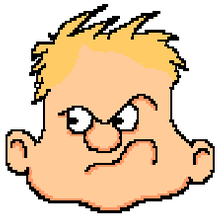

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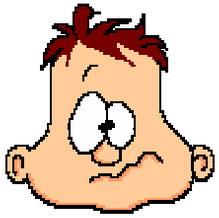

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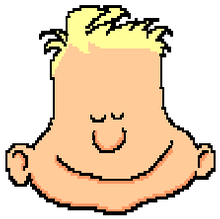

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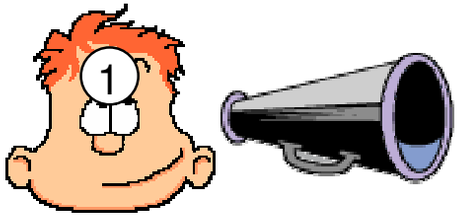

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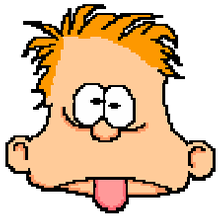

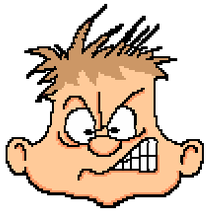

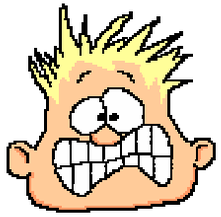

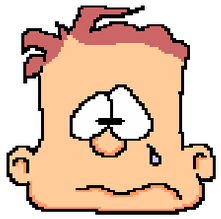

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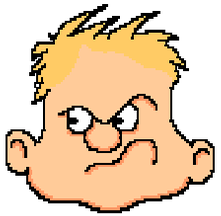

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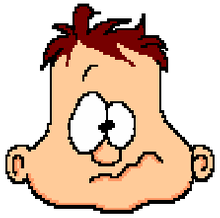

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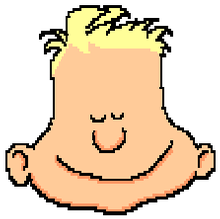

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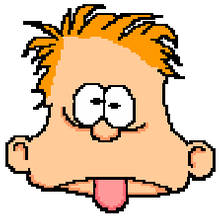

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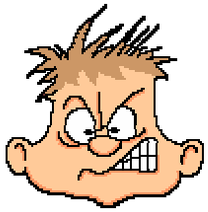

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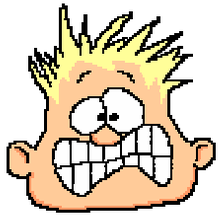

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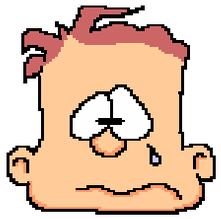

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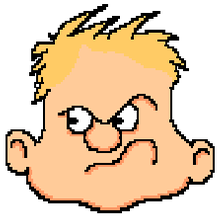
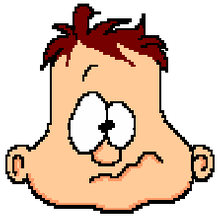
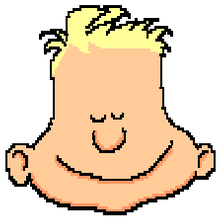
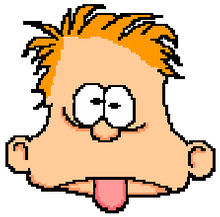






1 1

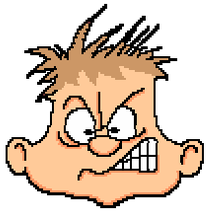
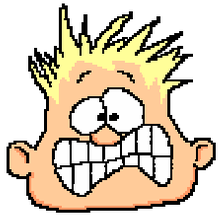
1 0

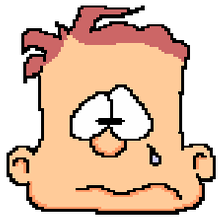
0 1

1 1

1 0

Pr(all coins are 1) = ??

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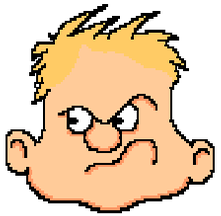
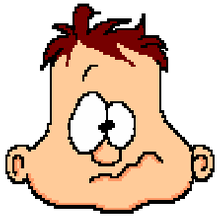
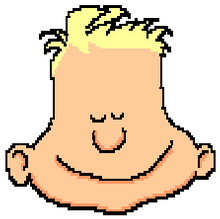
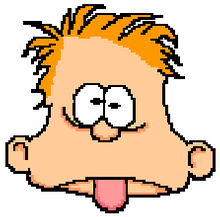






1 1

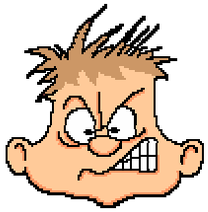
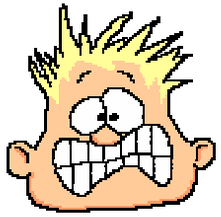
1 0

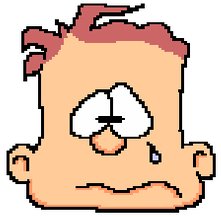
0 1

1 1

1 0

$$\Pr(\text{all coins are } 1) = 2^{-10}$$

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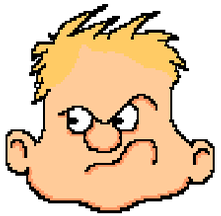
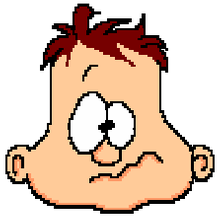
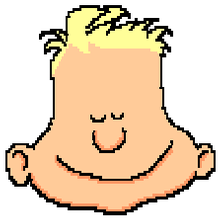

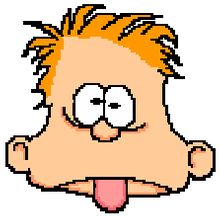
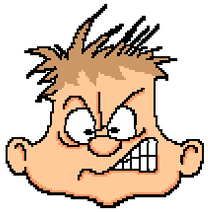
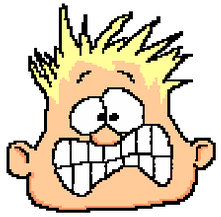

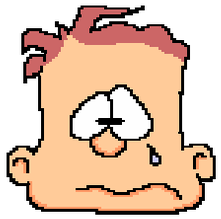


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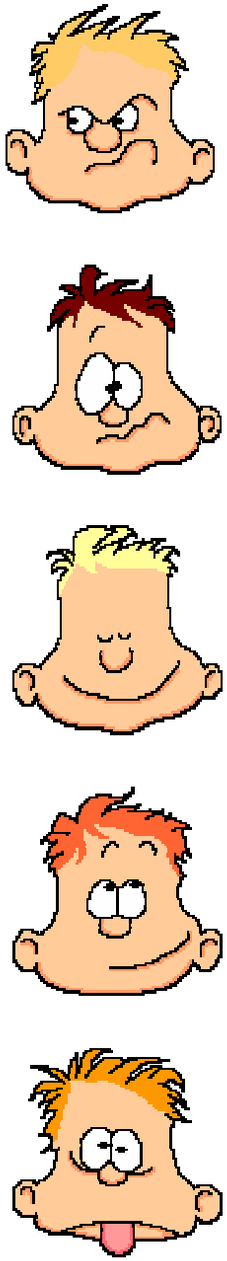
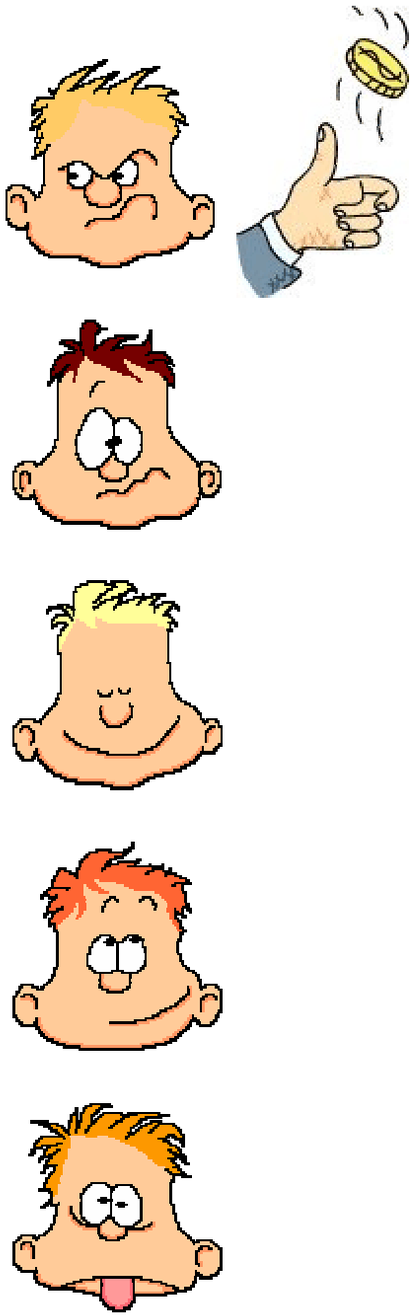


Goal: all coins are 1

An Example



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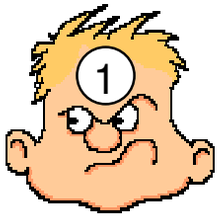

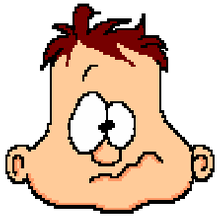

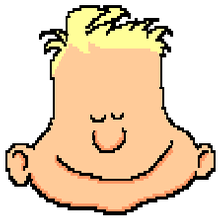

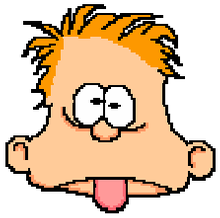

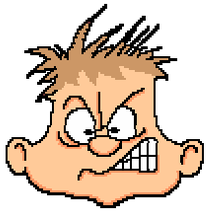

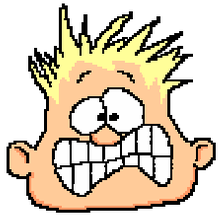

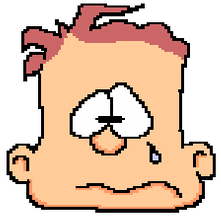

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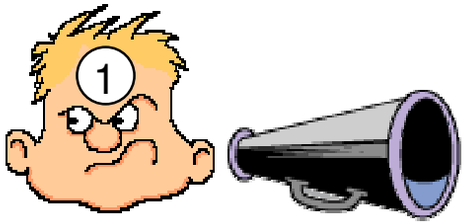

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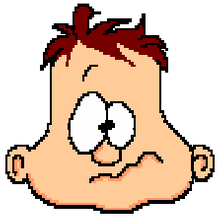

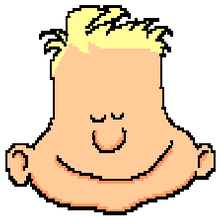

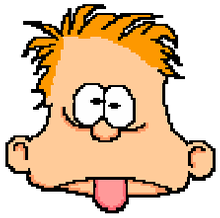

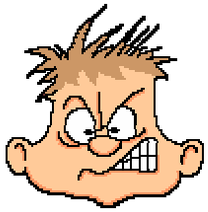

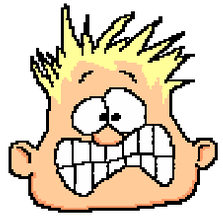

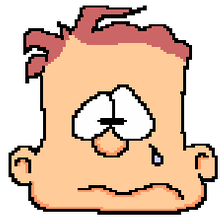

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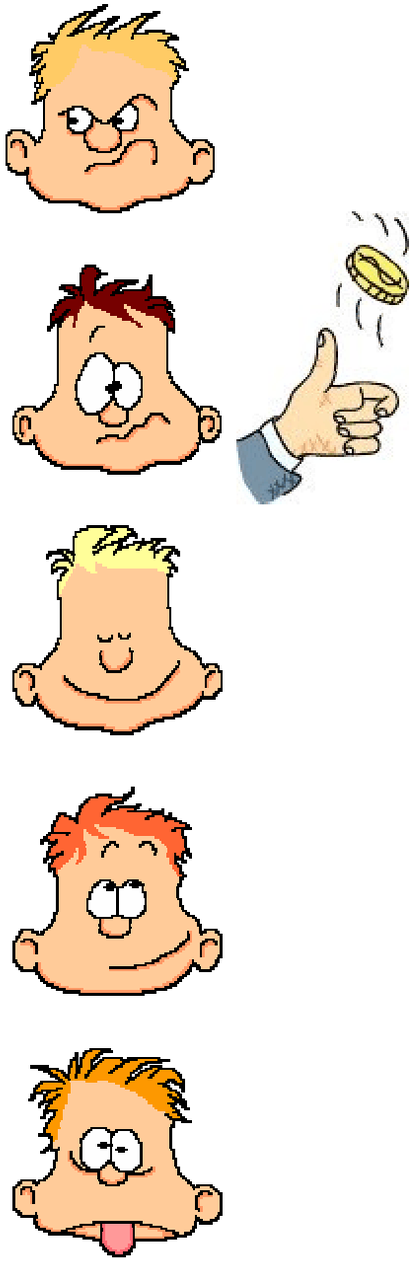

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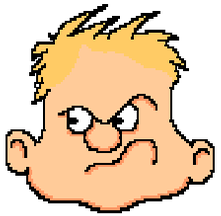

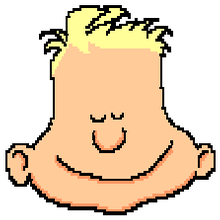

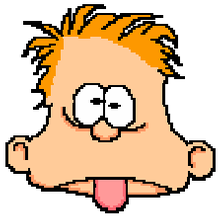

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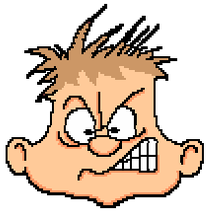

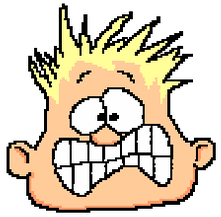

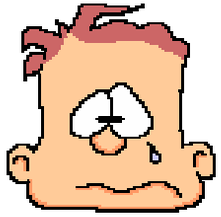

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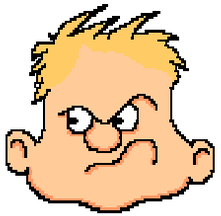

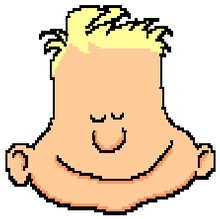

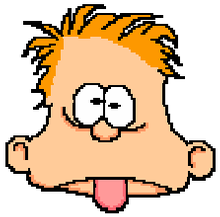

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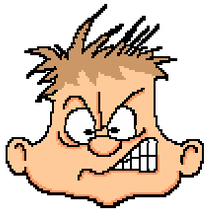

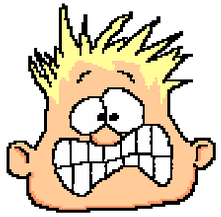

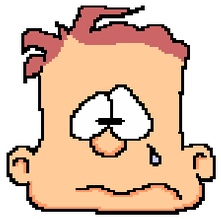

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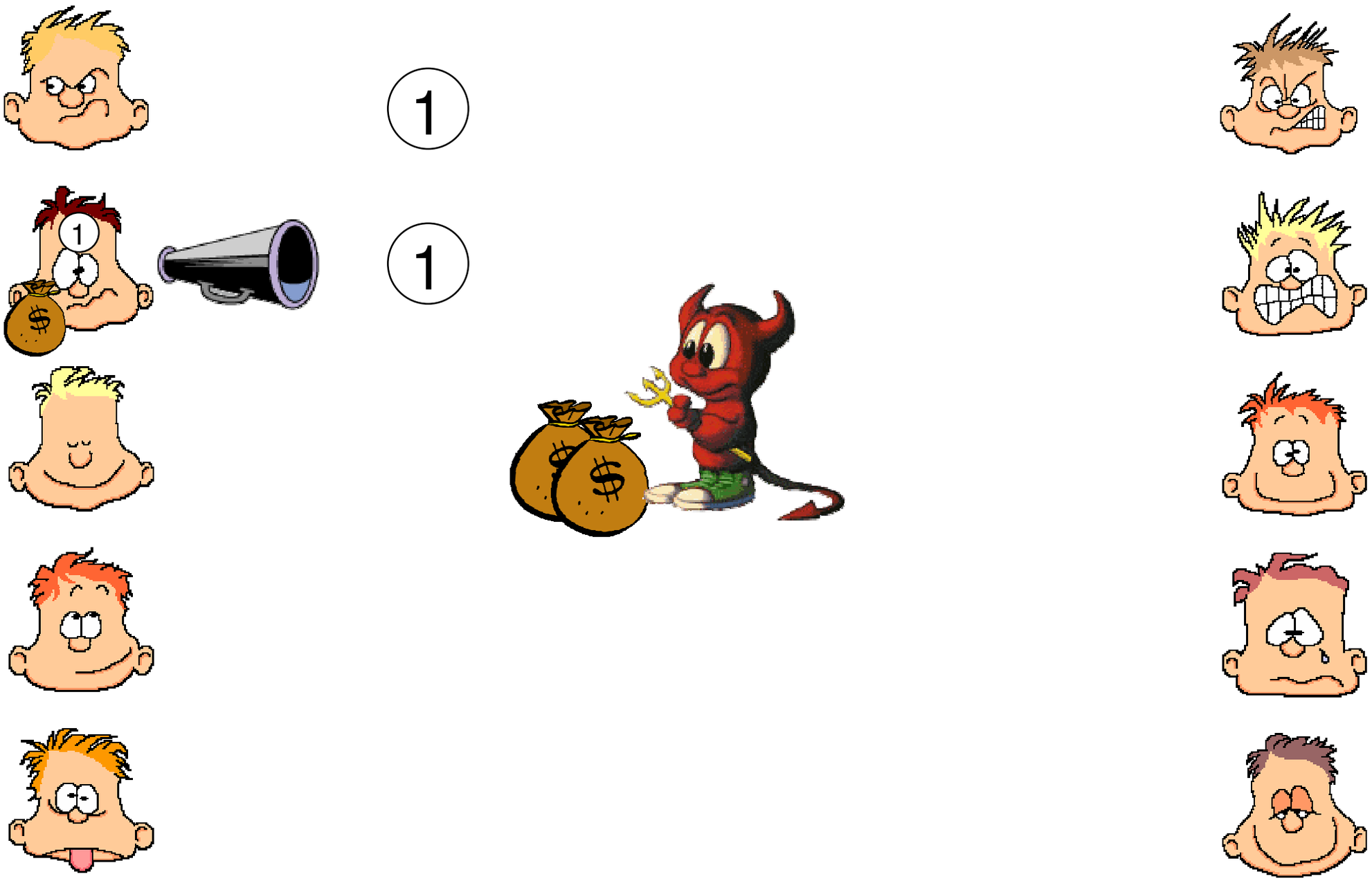

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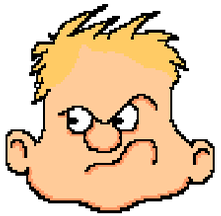

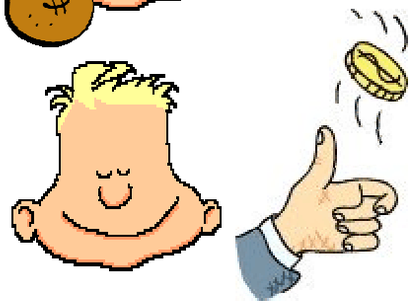

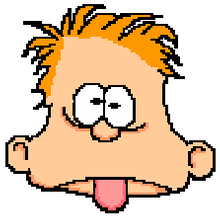

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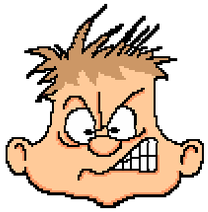

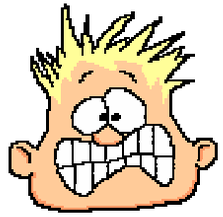

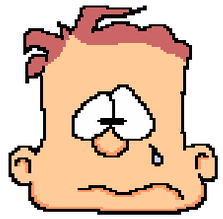

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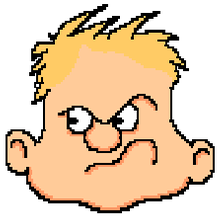

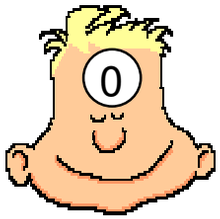

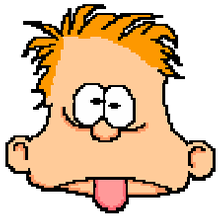

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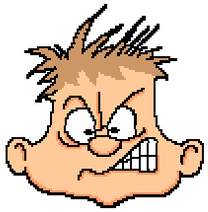

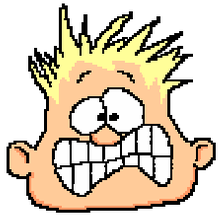

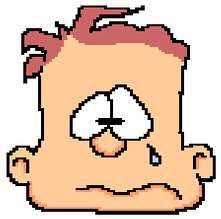

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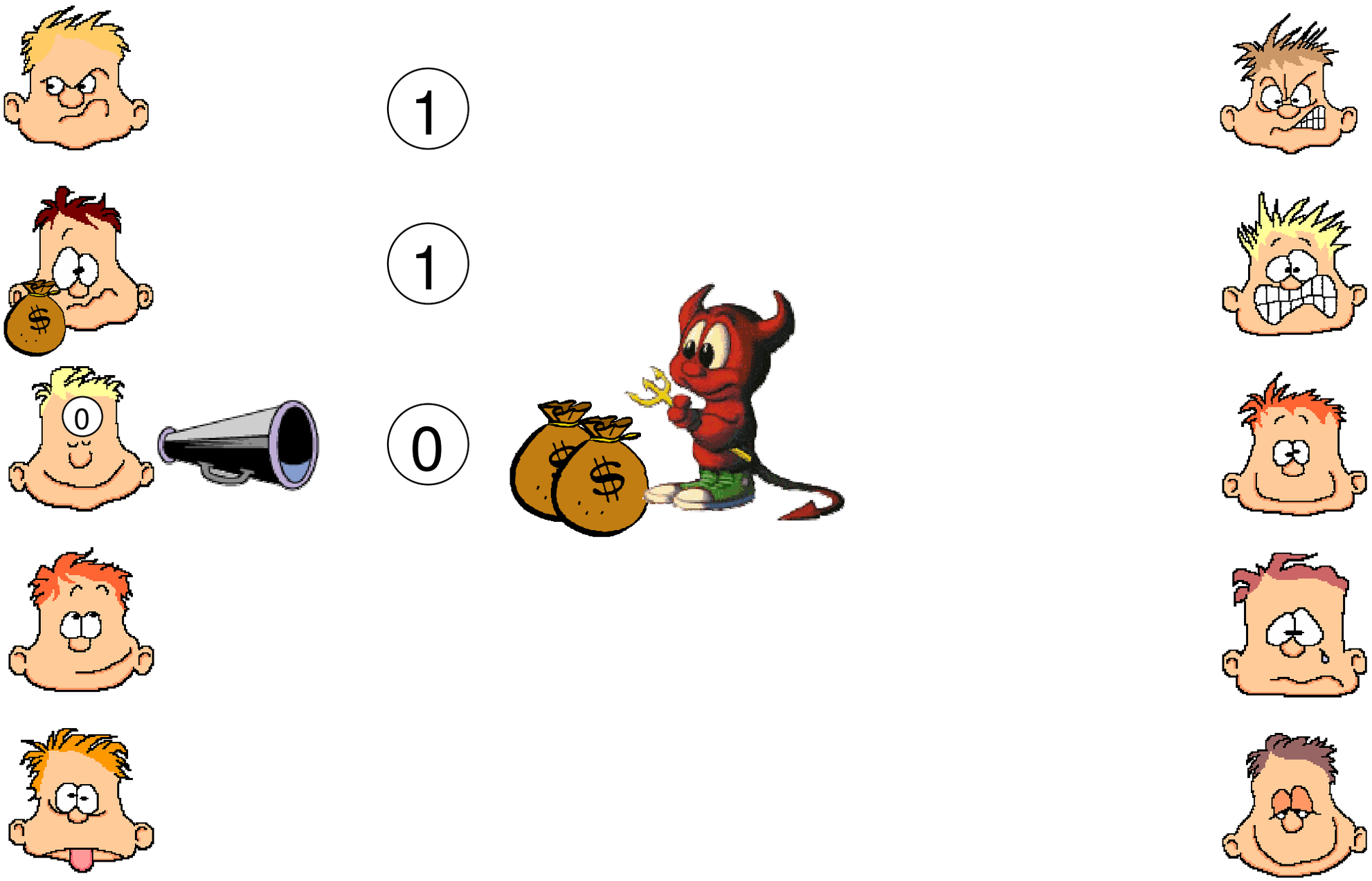

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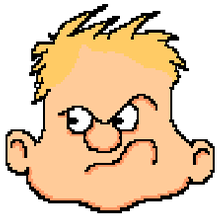

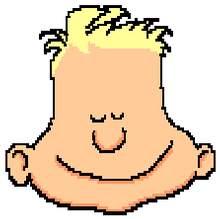

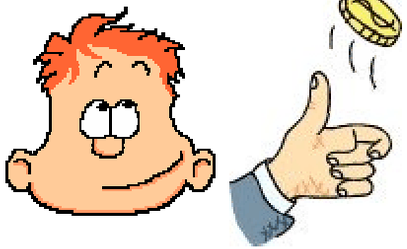

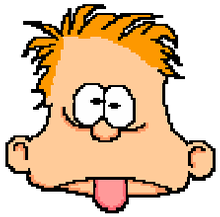

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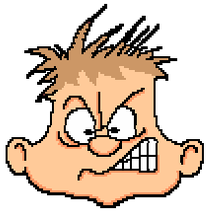

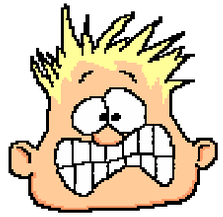

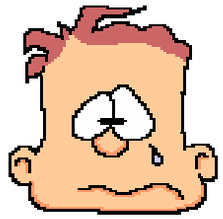

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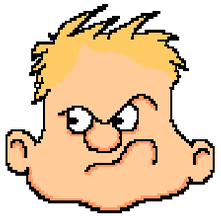

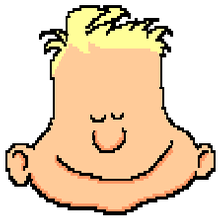

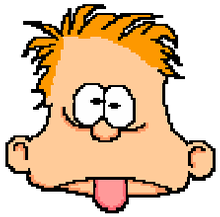

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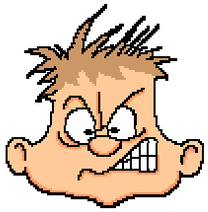

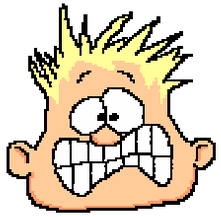

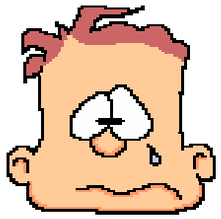

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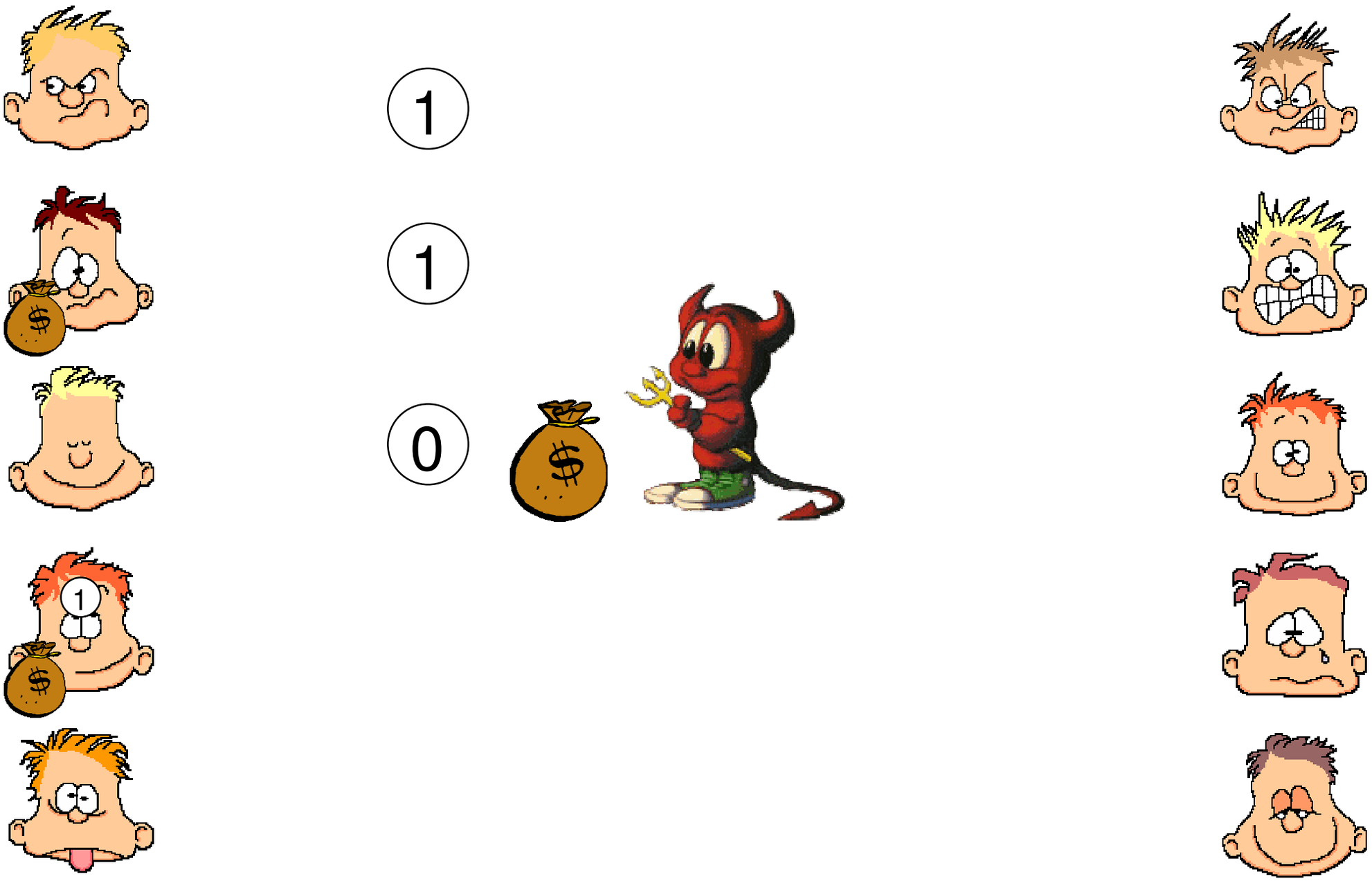

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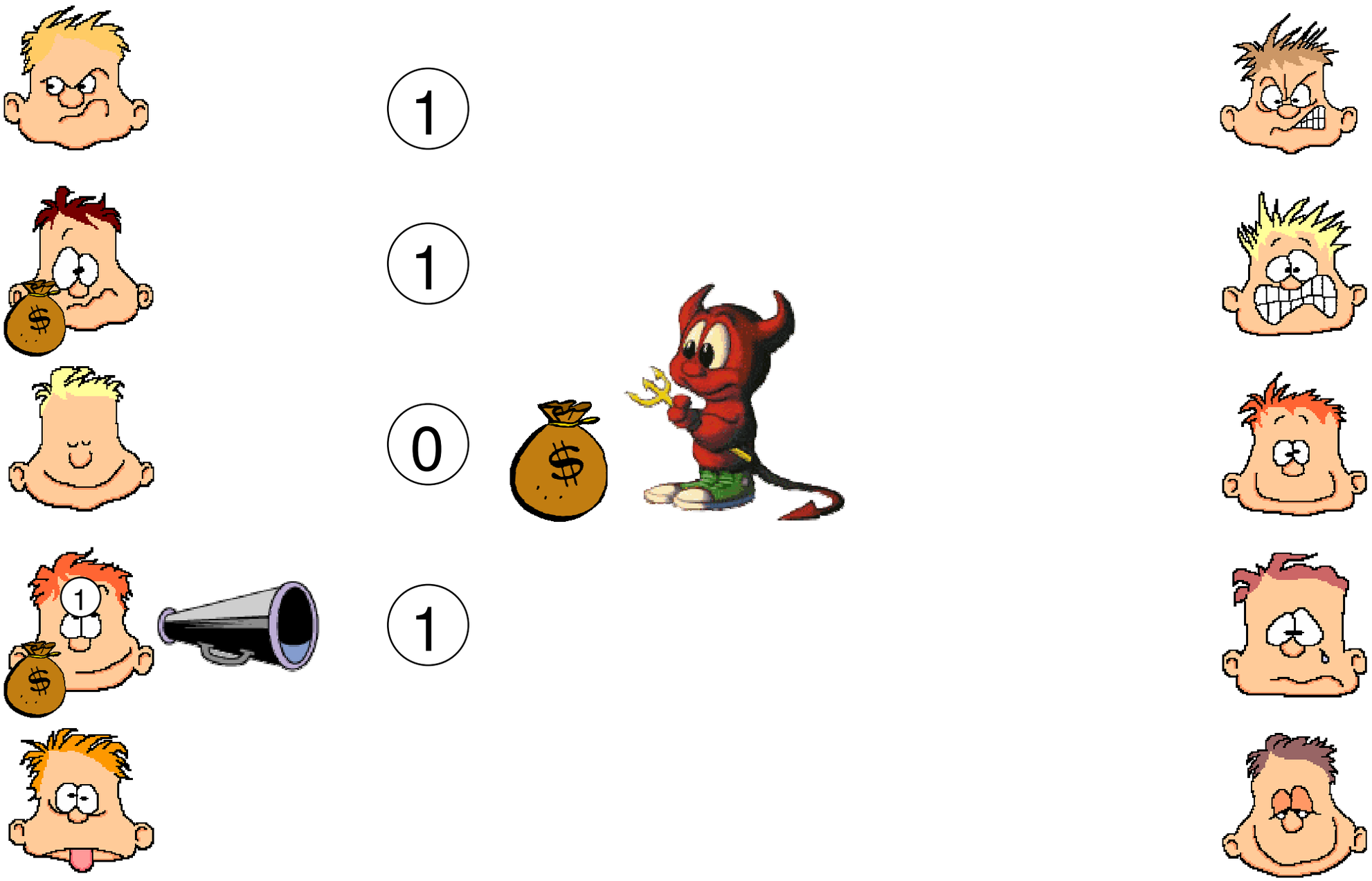

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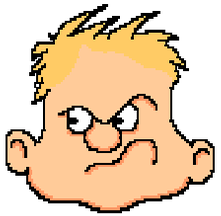

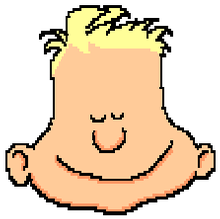

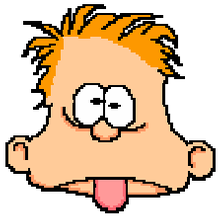

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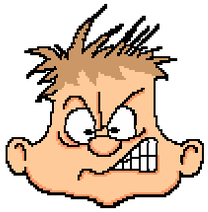
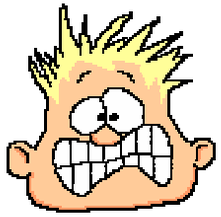

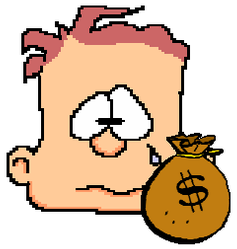


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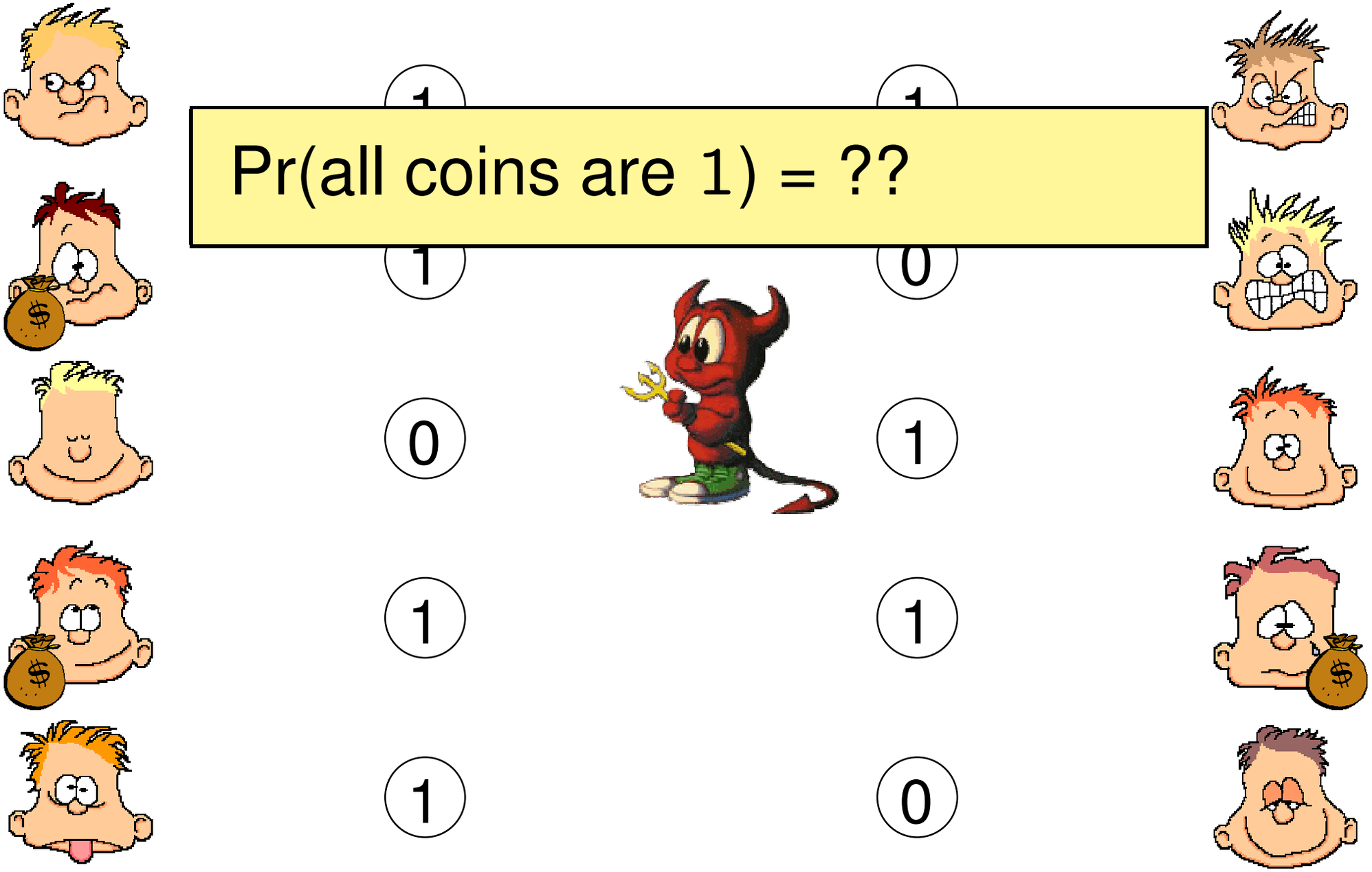
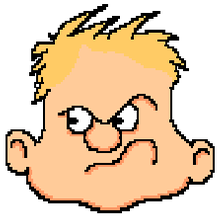
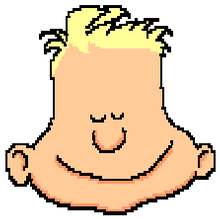
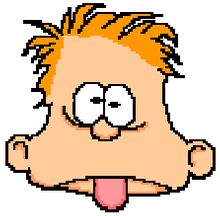


Pr(all coins are 1) = ??

An Example







$$\Pr(\text{all coins are } 1) = 2^{-7} \approx 1\%$$

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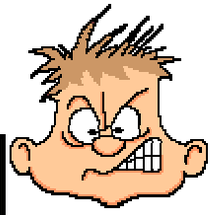
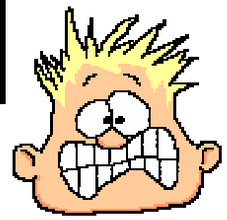

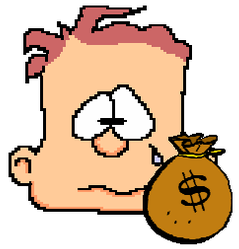


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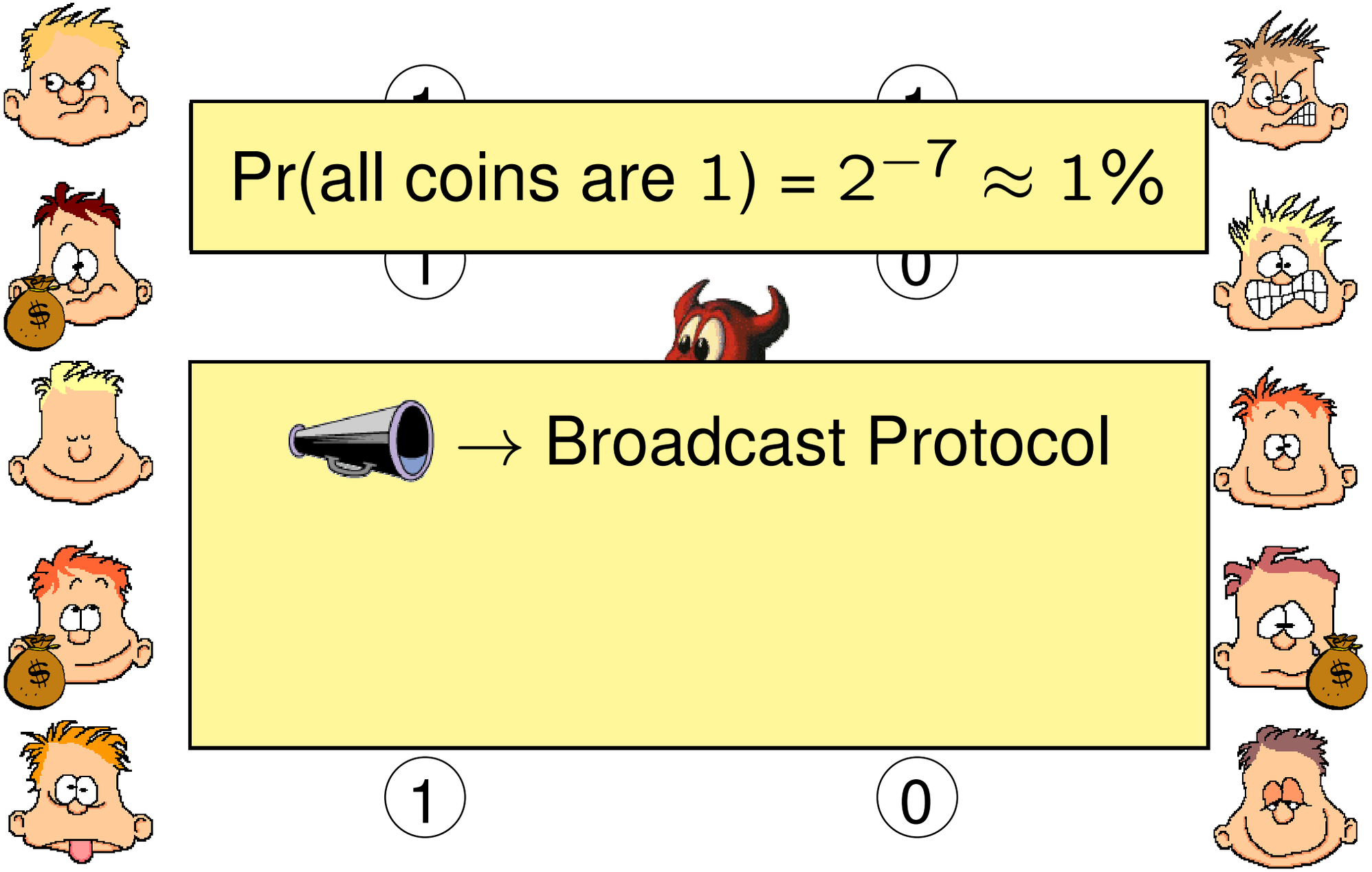
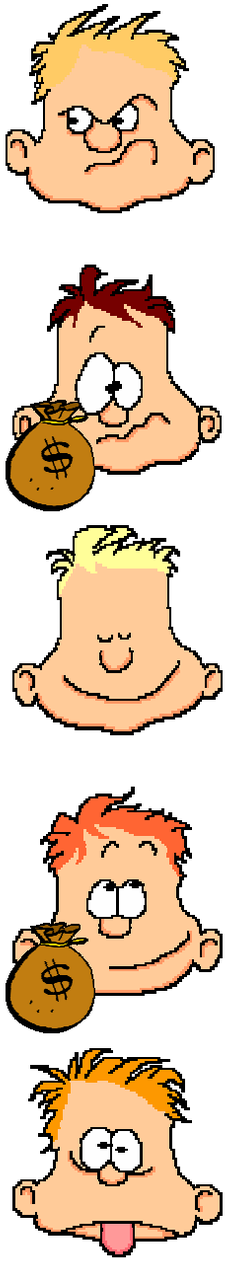
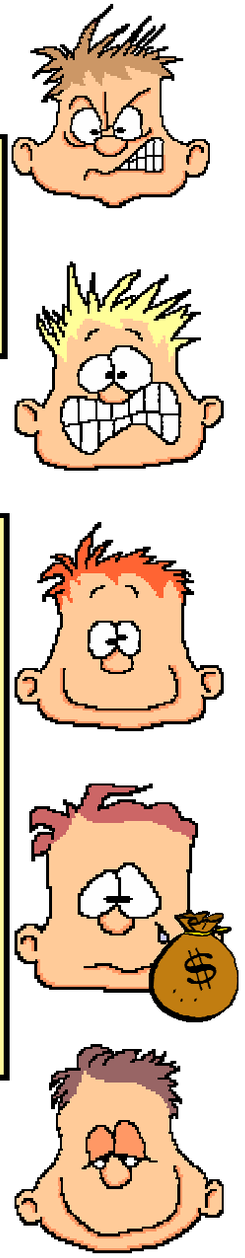


$$\Pr(\text{all coins are } 1) = 2^{-7} \approx 1\%$$

$\rightarrow$ Broadcast Protocol

An Example

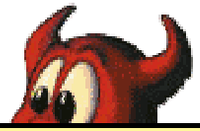


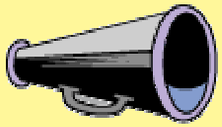


1 1

$$\Pr(\text{all coins are } 1) = 2^{-7} \approx 1\%$$

1 0





$\rightarrow$ Broadcast Protocol

[LSP,DS,BGP,CW,LLR,. . .]

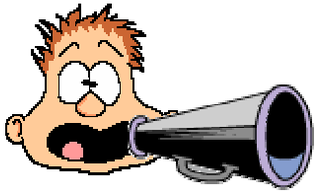
$$\Pr(\text{all coins are } 1) \approx 9\%$$

1 0

The Problem

The Expectation

Broadcast Protocol $\equiv$



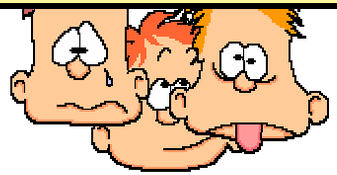
The Problem

The Expectation

Functionality (informal)

1. Sender $\xrightarrow{x} \mathcal{F}$
2. $\mathcal{F} \xrightarrow{x}$ all recipients

Bro



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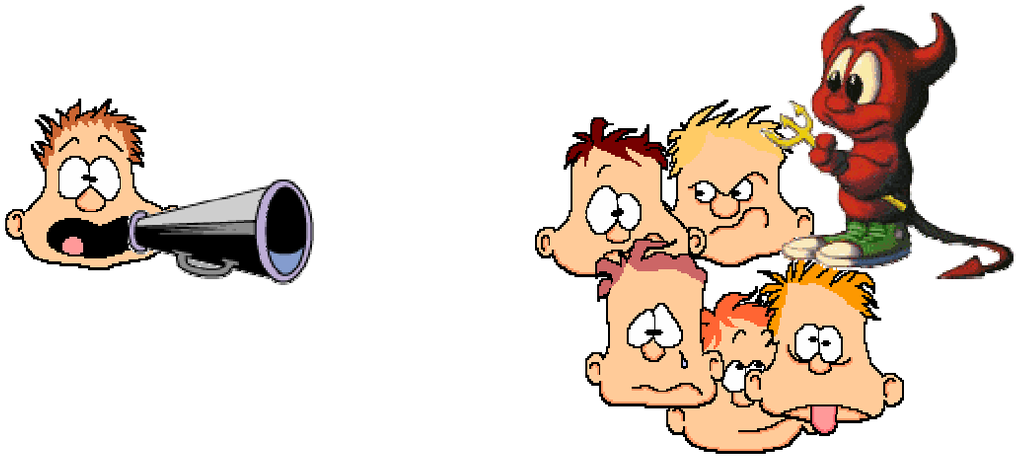
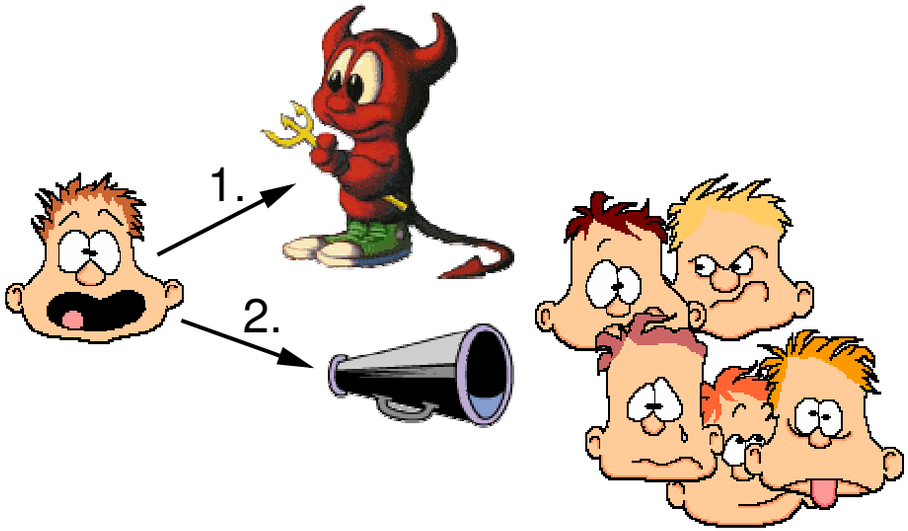


The Reality

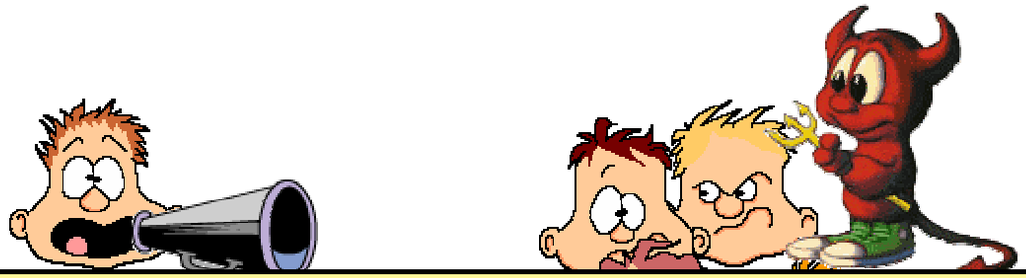
Broadcast Protocol $\equiv$



The Problem

The Expectation

Broadcast Protocol $\equiv$



Functionality (informal)

1. Sender $\xrightarrow{x} \mathcal{F}$
2. $\mathcal{F} \xrightarrow{x}$ Adv
3. Adversary can corrupt sender
4. If Sender is corrupted: Adv $\xrightarrow{x'} \mathcal{F}$

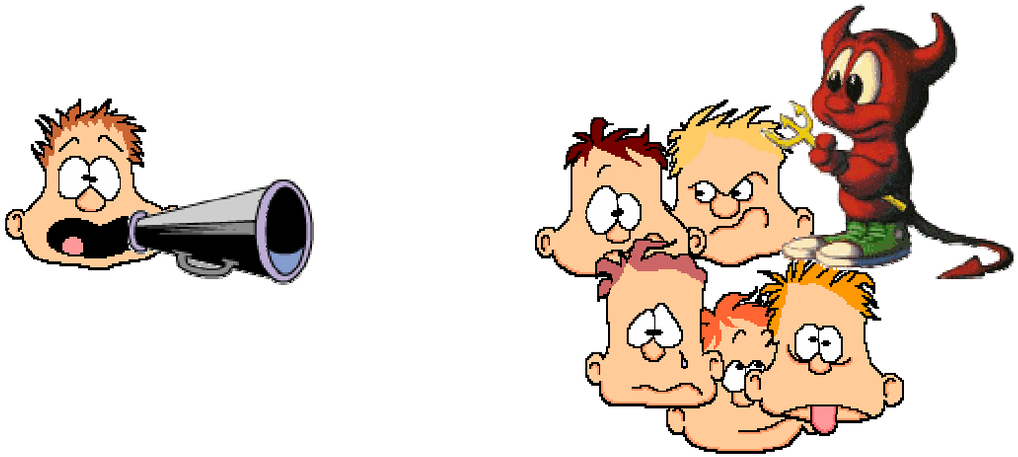
   Otherwise: $\mathcal{F}$ sets $x' = x$
5. $\mathcal{F} \xrightarrow{x'}$ all recipients

The Problem

The Expectation

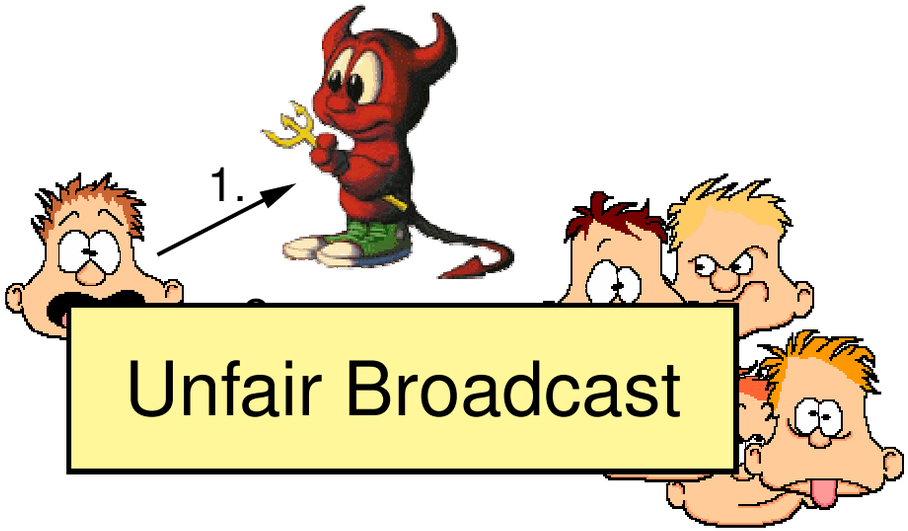
Fair Broadcast

Broadcast Protocol $\equiv$



The Reality

Broadcast Protocol $\equiv$



Unfair Broadcast

Outline

Talk Outline

- Motivation
- Known Broadcast Protocols
- Our Broadcast Protocols
- Conclusions

Known Broadcast Protocols

Sample Broadcast Protocol [LSP,DS,BGP,CW,LLR,. . .]

1. Sender sends x to all players
2. Players . . .
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The Attack

- Adversary gets x in Step 1 *before honest players*.
- If Adversary does not like x, she *corrupts Sender*, and *sends* x' to honest players.

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$\Rightarrow$ **Unfair Broadcast**

Known Broadcast Protocols

S

1

2

3

Property-Based Definition of Broadcast

- **Consistency**: All players receives the same value.
- **Validity**: Sender correct $\Rightarrow$ this is his value.
- **Termination**: Every player eventually receives value.

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Known Broadcast Protocols

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Simultaneous Broadcast

- different senders, ensure independence of messages
- [CGMA85,CR87,Gen95,Gen00,HM05,Hev06,...]
- use broadcast as sub-protocol (property based :-S)

$\Rightarrow$ **Unfair Broadcast**

Known Broadcast Protocols

Sample Broadcast Protocol [LSP,DS,BGP,CW,LLR,. . .]

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2. Players . . .
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$\Rightarrow$ **Unfair Broadcast**

Known Broadcast Protocols

Secure Channels Model — Synchronous

- maximum network delay, common clock
- no minimum network delays!
- no simultaneous multi-send
- small clock skews allowed

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Known Broadcast Protocols

Secure Channels Model — Synchronous

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Dolev-Strong Broadcast [DS82]

- unfair even with simultaneous multi-send

sends x' to honest players.

$\Rightarrow$ **Unfair Broadcast**

Known Broadcast Protocols

Secure Channels Model — Synchronous

- maximum network delay, common clock
- no minimum network delays!
- no simultaneous multi-send
- small clock skews allowed

Dolev-Strong Broadcast [DS82]

Dual-Failure Model [GP92]

- active and fail corruptions
- fail during send $\rightarrow$ unfair

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Adaptively Secure Broadcast

Considered Model

- secure channels model, synchronous
- same problem apparently also in other models

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Without Setup

- known: unfair broadcast: $t < n/3$
- fair broadcast (megaphone): $t < n/3$

Adaptively Secure Broadcast

Considered Model

- secure channels model, synchronous
- same problem apparently also in other models

Without Setup

- known: unfair broadcast: $t < n/3$
- fair broadcast (megaphone): $t < n/3$

With Setup (i.t. or crypto.)

- known: unfair Broadcast: $t < n$
- fair broadcast (megaphone): $t \leq n/2$
- assumes signature functionality

Fair Broadcast w/o Setup — $t < n/3$

Approach

- 1. VSS [BGW88], 2. Reconstruct
- VSS uses broadcast, deploy with unfair broadcast
- Analysis (white box) $\rightarrow$ still secure

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VSS [BGW88]

1. Dealer distributes some polynomials to each player
2. Players pairwisely check consistency
3. Inconsistency $\rightarrow$ complain by broadcast
4. Dealer broadcasts correct value, goto 3

Fair Broadcast w/o Setup — $t < n/3$

Analysis

- Broadcasted values are known to adv. *at beforehand*
- $\rightarrow$ fair broadcast $\approx$ unfair broadcast

- Analysis (white box) $\rightarrow$ still secure

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- 1. VSS [BGW88], 2. Reconstruct
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- Analysis (white box) $\rightarrow$ still secure

Optimality ($t < n/3$)

- follows directly from necessity for unfair broadcast

Fair Broadcast w/ Setup — $t \leq n/2$

Approach 1

- 1. VSS [CDDHR99], 2. Reconstruct
- VSS uses broadcast $\rightarrow$ deploy with unfair broadcast
- Analysis (white box) $\rightarrow$????

Fair Broadcast w/ Setup — $t \leq n/2$

Approach 1

- 1. VSS [CDDHR99], 2. Reconstruct
- VSS uses broadcast $\rightarrow$ deploy with unfair broadcast
- Analysis (white box) $\rightarrow$????

Approach 2

- 1. VSS, 2. Reconstruct
- pimp VSS from [CDDHR99], use signatures,

  adjust complaints and accusations (see paper)
- $t \leq n/2$: correctness only guaranteed for honest dealers

Fair Broadcast w/ Setup — $t \leq n/2$

Optimality ($t \leq n/2$)

- Assume π for $t > n/2$.
- Sender p_S, $n-1$ recipients R, $t-1 \geq |R|/2$.
- No simultaneous multi-send $\rightarrow$ proceed msg by msg.
- After each msg, some $A \subseteq R$ obtain information on x.
- Consider first $A \subseteq R$ with $|A| \geq t-1$.
- Observe: $B = R \setminus A$ has no information on x.
- Adversary can corrupt A, and, *depending on* x, can corrupt p_s (in total t players).

Conclusions

Known Broadcast Protocols

- do not realize natural functionality (megaphone)
- **use with care!**

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better: don’t use it ;-)

Conclusions

Known Broadcast Protocols

- do not realize natural functionality (megaphone)
- **use with care!**

better: don't use it :-)

care = prove your protocol secure

Conclusions

Known Broadcast Protocols

- do not realize natural functionality (megaphone)
- **use with care!**

New Broadcast Protocol

- (slightly) less efficient
- requires $t \leq n/2$ (this is optimal)
- **plug-and-play usage**

Conclusions

Known Broadcast Protocols

-
-

Thank You

Ne

-
- requires $t \leq n/2$ (this is optimal)
- **plug-and-play usage**

TOC