

Dynamic Traitor Tracing for Arbitrary Alphabets:

Divide and Conquer

*Thijs Laarhoven, Jan-Jaap Oosterwijk (TU/e)
Jeroen Doumen (Irdeto)*



MB
Milton Bradley

Does your person
have a big nose?

No

Is your person
wearing a hat?

Yes

I know!
It's Maria!

**Ages
6 and Up**

Guess your
opponent's mystery
person before your
opponent guesses
yours.

2 Players

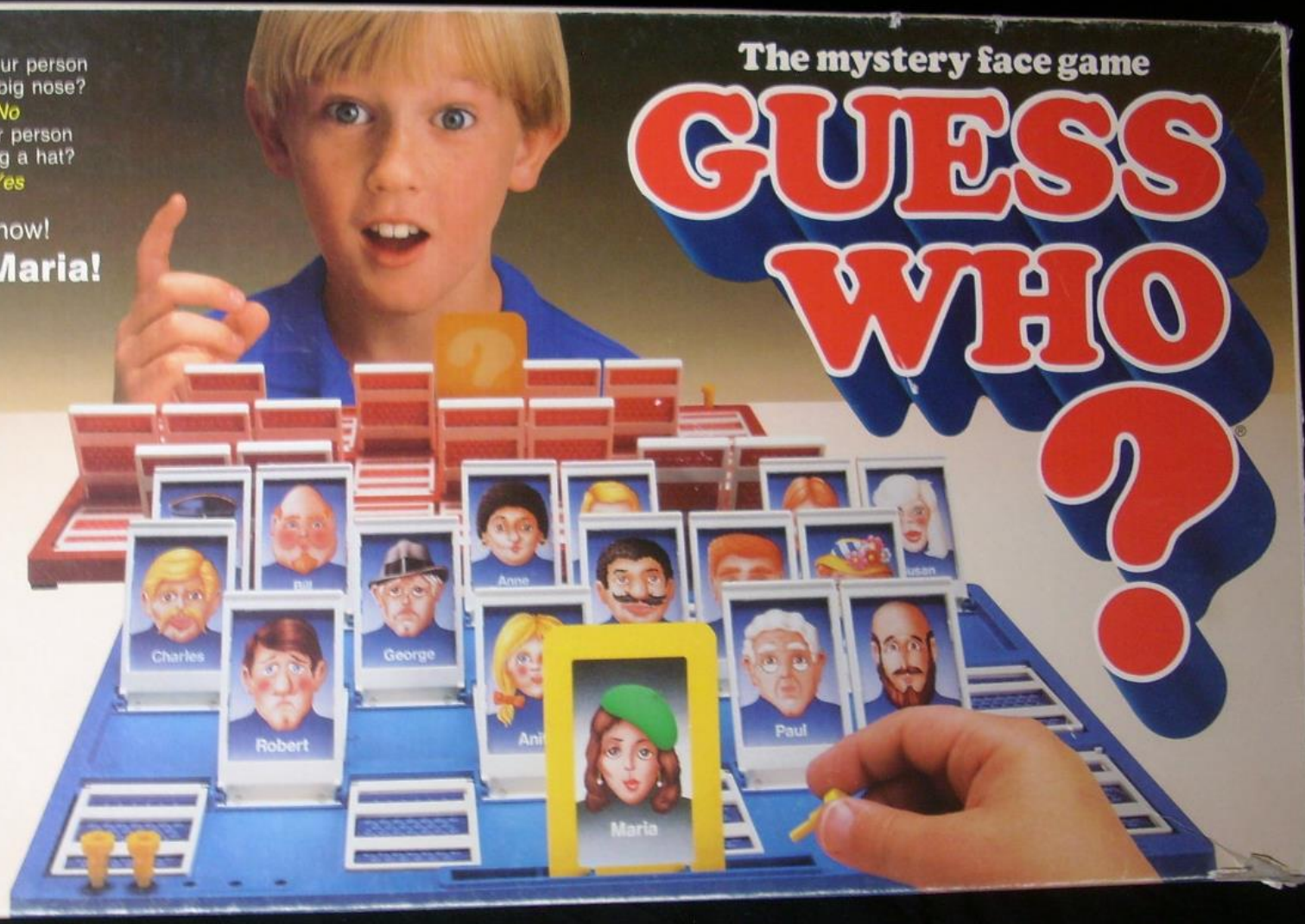
Game instructions in
English and Spanish.
Instrucciones del juego
en inglés y español.

Small marks like all
new Milton Bradley
and its logo.

Small marks like all
new Milton Bradley
and its logo.

The mystery face game

**GUESS
WHO?**



“Guess Who ?”

ΜΑΝΤΕΨΕ ΠΟΙΟΣ? ¿Quién Es Quién? Cara a Cara

Wie Is Het? Indovina Chi? Gjett Hvem? Qui Est-Ce?

Hvem Er Hvem? Hvem Kan Det Vaere, Nahesh Mi?

Vem Dar? Wer Ist Es? Quem É Quem? Ugani Kdo?

Zgadnij Kto To? Pogodi Tko, Arvaa Kuka? ...

“Guess Who ?” (1979)

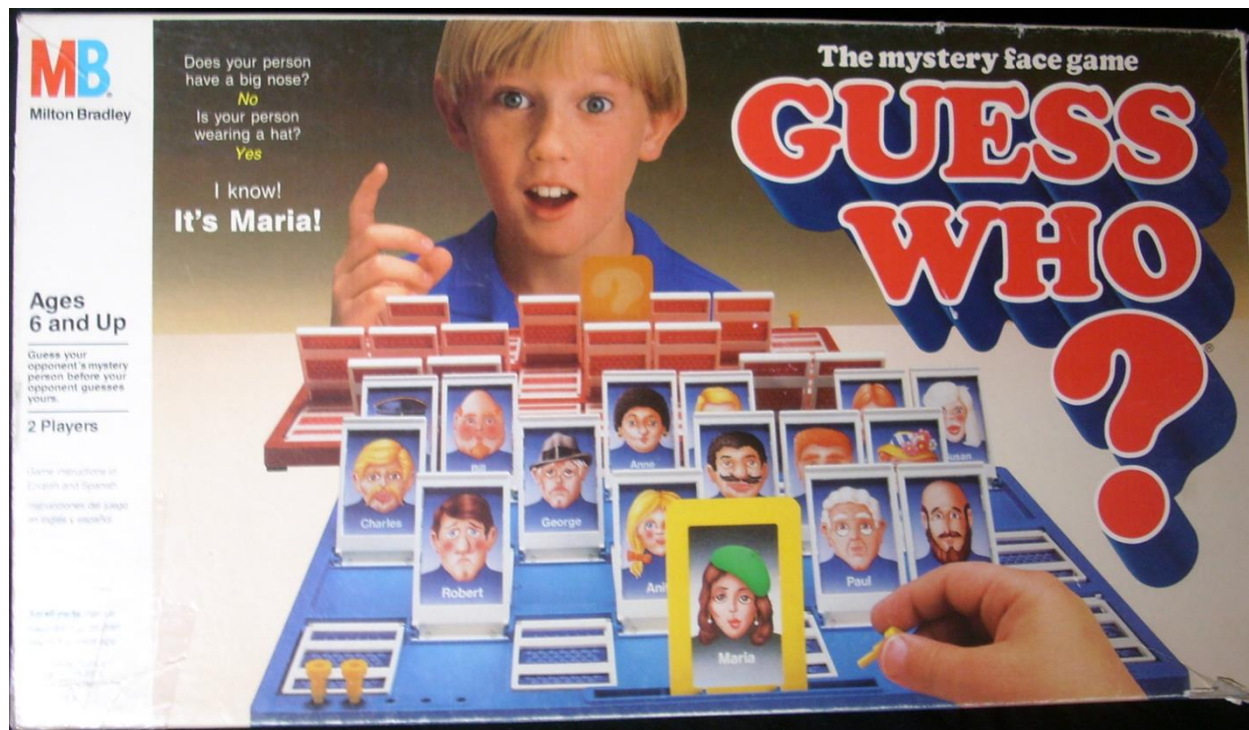
- **THEORA DESIGN** (Theo & Ora Coster) 



- 1979: New Zealand, UK, Greece, Spain, France, Netherlands
- 1980: Italy
- 1982: USA (Lakeside)
- 1986: Brazil (Estrela), Norway, Denmark, Argentina
- 1987: Israel, Sweden, Mexico, Japan (Bandai), China
- ...

Rules of the Game

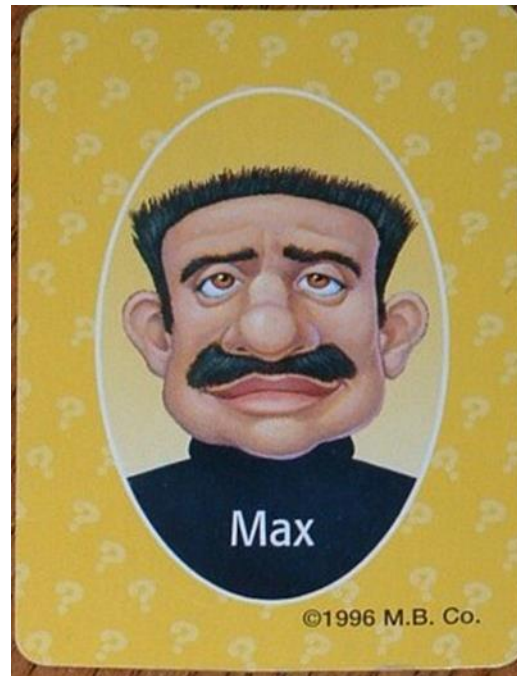
- Each player secretly draws **one out of n** face cards.



• ...ret card.
• ...rd, wins!

Example

- Q: Do you have red hair?
- A: No.
- Q: Are you a man?
- A: Yes



Rules of the Game

- Each player secretly draws **one out of n** face cards.
- Players take turns asking **yes/no questions**.
- The opponent answers **truthfully** for his secret card.
- The first player to **guess the opponent's card**, wins!

Solution: Binary search

- Number of questions needed: $\ell = O(\log n)$
- Always guess correctly after at most ℓ questions

“Guess Them!”

“Challenging Game for Advanced Players

*For an extra challenge, both players draw **two** Mystery cards, and place them side-by-side in their Mystery card slots. Your object is to guess who **both** of your opponent's Mystery People are.”*

- Each player secretly draws **c out of n** cards.
- Players take turns asking yes/no questions.
- The opponent answers truthfully for **one of his c cards**.
- The first player to **guess all opponent's cards**, wins!

Example

- Q: Do you have red hair?
- A: No.
- Q: Are you a man?
- A: Yes



Solution

Tardos ('03), Laarhoven et al. ('11)

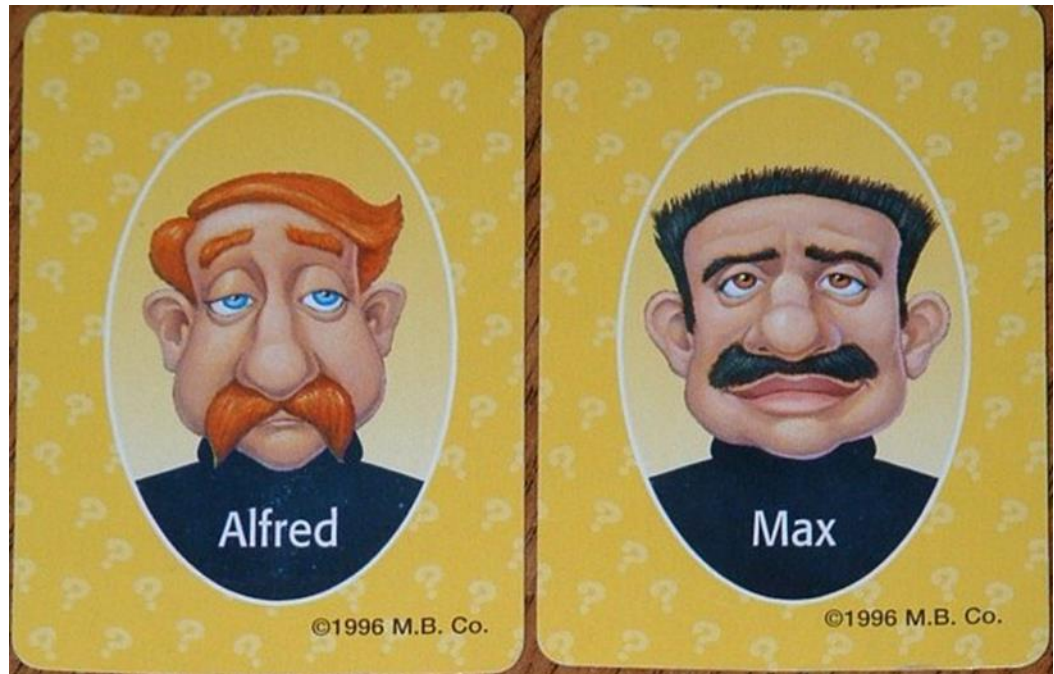
- Number of questions needed: $\ell = O(c^2 \log n/\varepsilon)$
- Probability of error: ε

“Guess Them by Multiple Choice”

- Each player secretly draws c out of n cards.
- Players take turns asking **multiple choice** questions.
- (Number of choices: $q > 2$)
- The opponent answers truthfully for one of his c cards.
- The first player to guess all opponent's cards, wins!

Example

- **Q: Do you have blond, black, brown or red hair?**
- **A: Red hair.**



Solution

Divide and Conquer ('12)

- **Divide** the group in smaller groups (men and women)
- Use yes/no questions for **each** group (as before)
- When no answer is returned, **repeat** the question!

Example

Group 1: **Men**

Q1 Blond hair?

A1 **No.**

Q2 Moustache?

A2

Q3 Moustache?

A3

Q4 Moustache?

A4 **No.**

Group 2: **Women**

Blond hair?

Blond hair?

Yes.

Blue eyes?

No.

Big nose?

Results

Linear tradeoff between q and ℓ

- For $q = 4$, half as many questions needed as for $q = 2$.
- Can be generalized to arbitrary values of q .
- Number of questions needed: $\ell = O(c^2/q \log n/\varepsilon)$

Actual Application

Copyright Protection

- Owner wants to know who created an **illegal** copy
- Insert **watermark** (unique features)
- **content segments ~ characteristics**
(hair color, eye color, ...)
- Even when people create a **mix** of their copies, they can be **traced**.

Workshop on Information Forensics

December 2th – 5th, 2012
Tenerife (Canary Islands)



MB
Milton Bradley

Does your person
have a big nose?

No

Is your person
wearing a hat?

Yes

I know!
It's Maria!

**Ages
6 and Up**

Guess your
opponent's mystery
person before your
opponent guesses
yours.

2 Players

Game instructions in
English and Spanish.
Instrucciones del juego
en inglés y español.

Small marks like all
new Milton Bradley
and its logo.

Small marks like all
new Milton Bradley
and its logo.

The mystery face game

**GUESS
WHO?**

