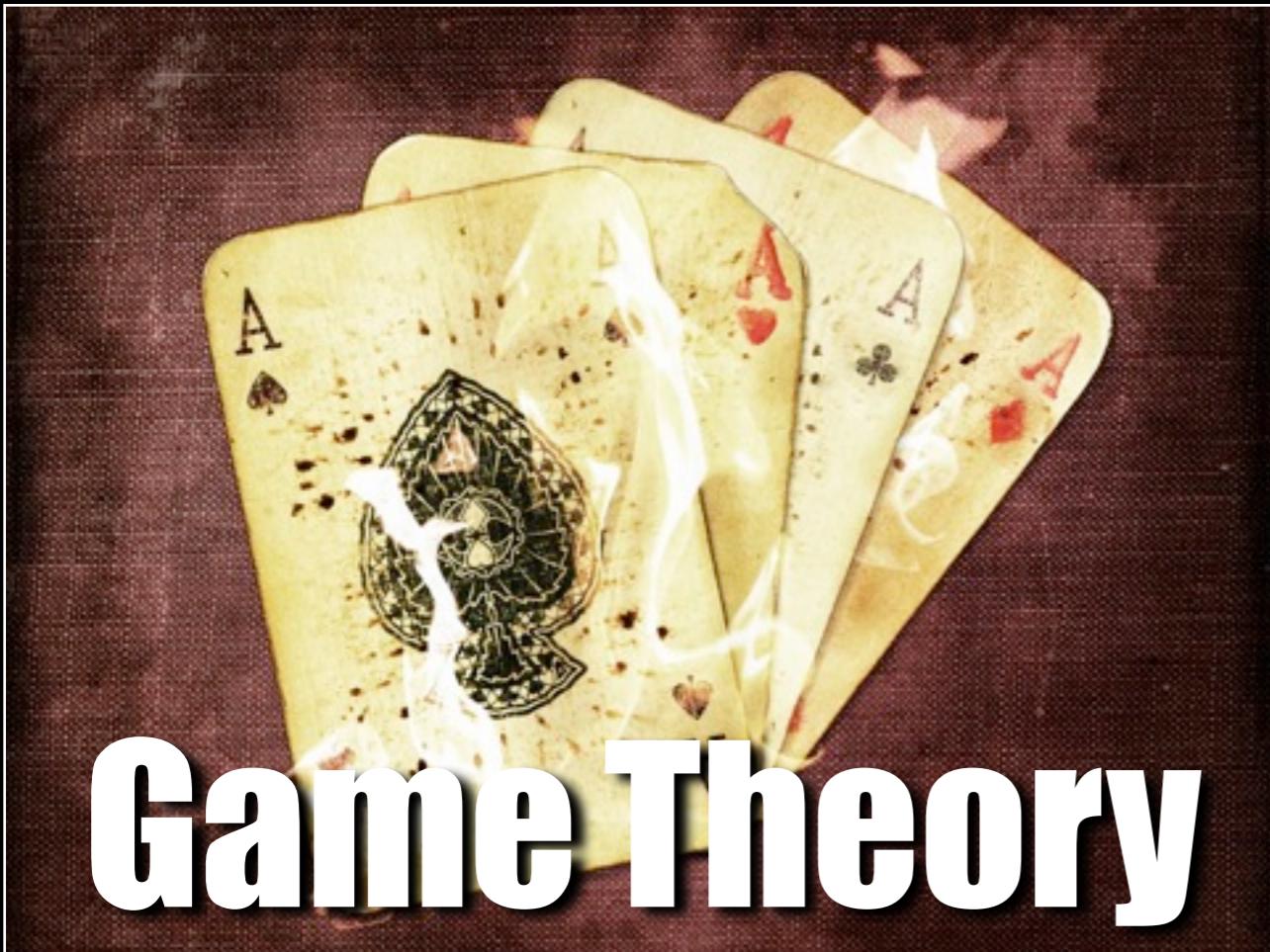


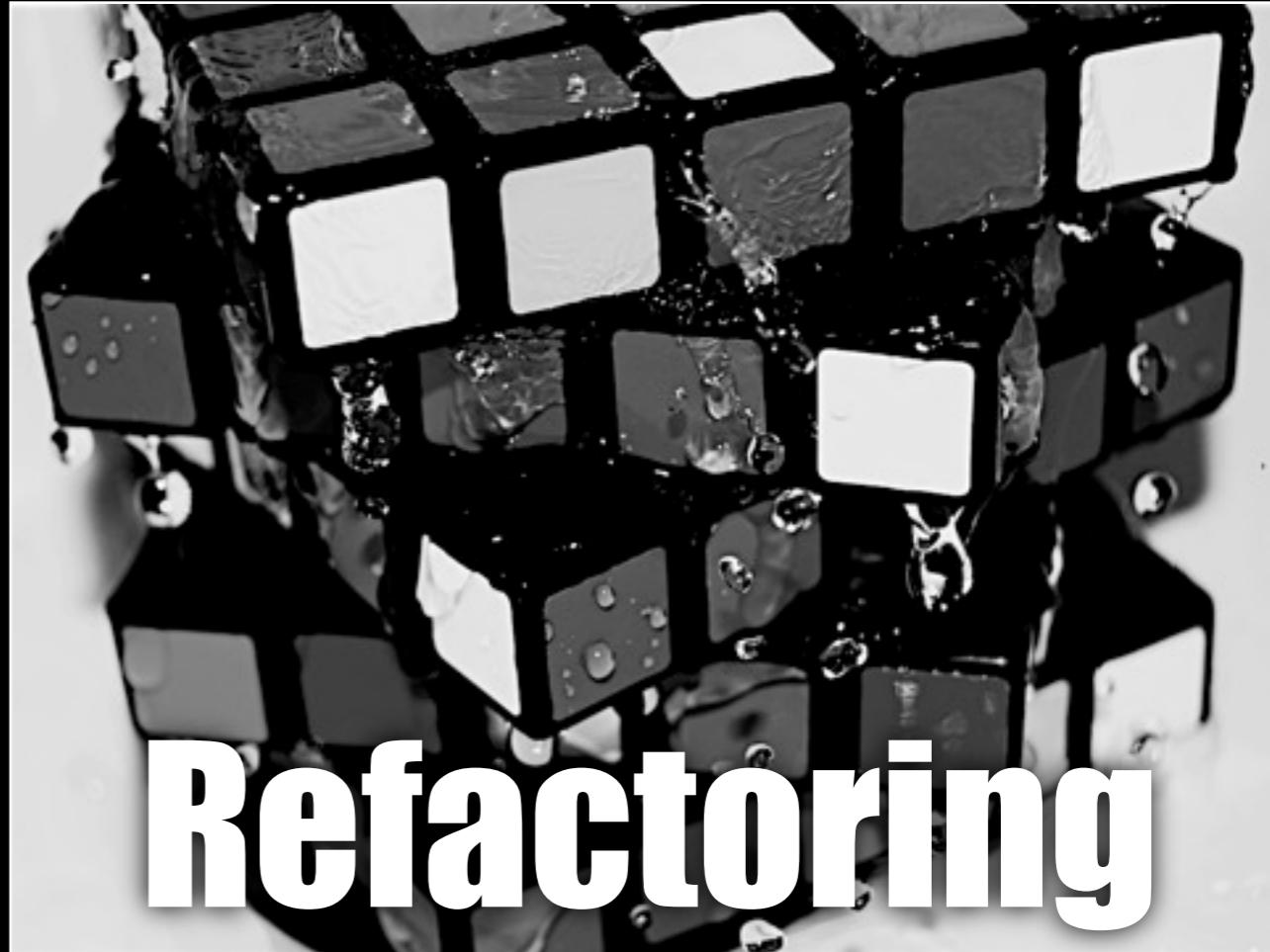
In Medio Stat Virtus: Extract Class Refactoring through Nash Equilibria

Gabriele Bavota, Rocco Oliveto, Andrea De Lucia,
Andrian Marcus, Yann-Gael Guéhéneuc, Giuliano Antoniol





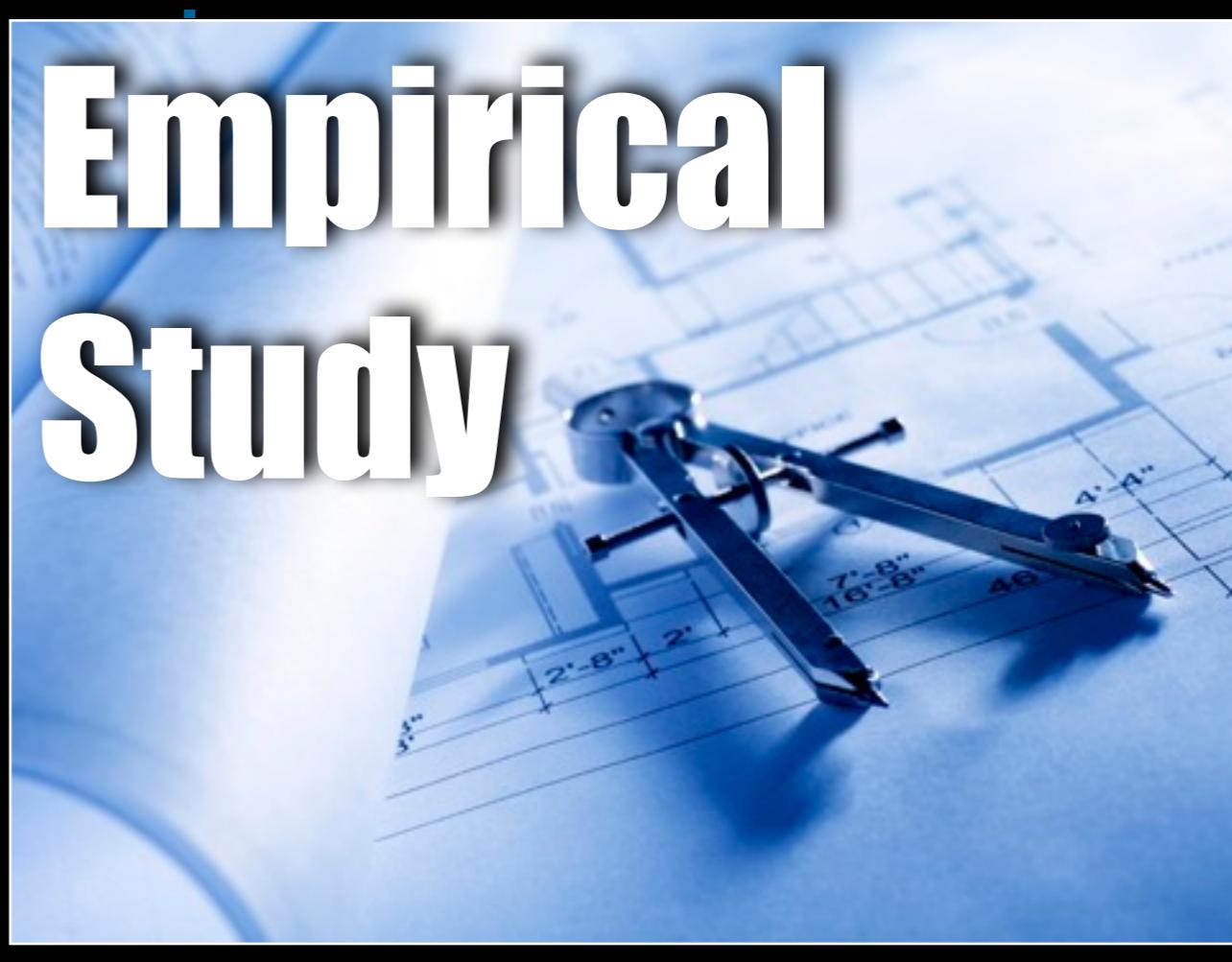
Game Theory



Refactoring

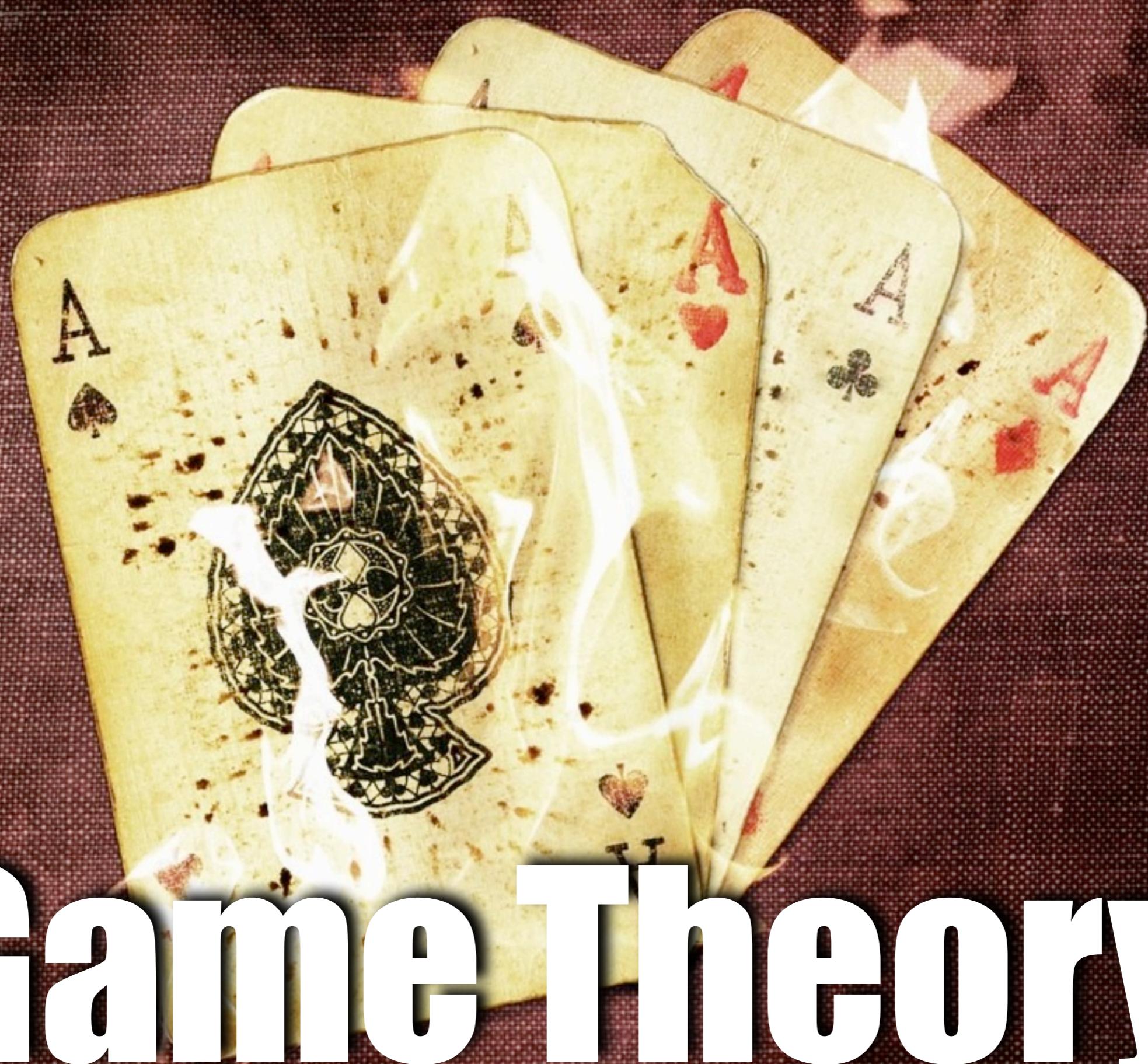


Approach



Empirical Study

Game Theory



Game Theory

A branch of mathematics, **capture behavior** in **strategic situations**, in which an individual's success in making choices depends on the choices of others

A game consists of:
a set of players
a set of moves available to those players
payoffs for each combination of moves



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The prisoner's dilemma



The prisoner's dilemma

SALLY

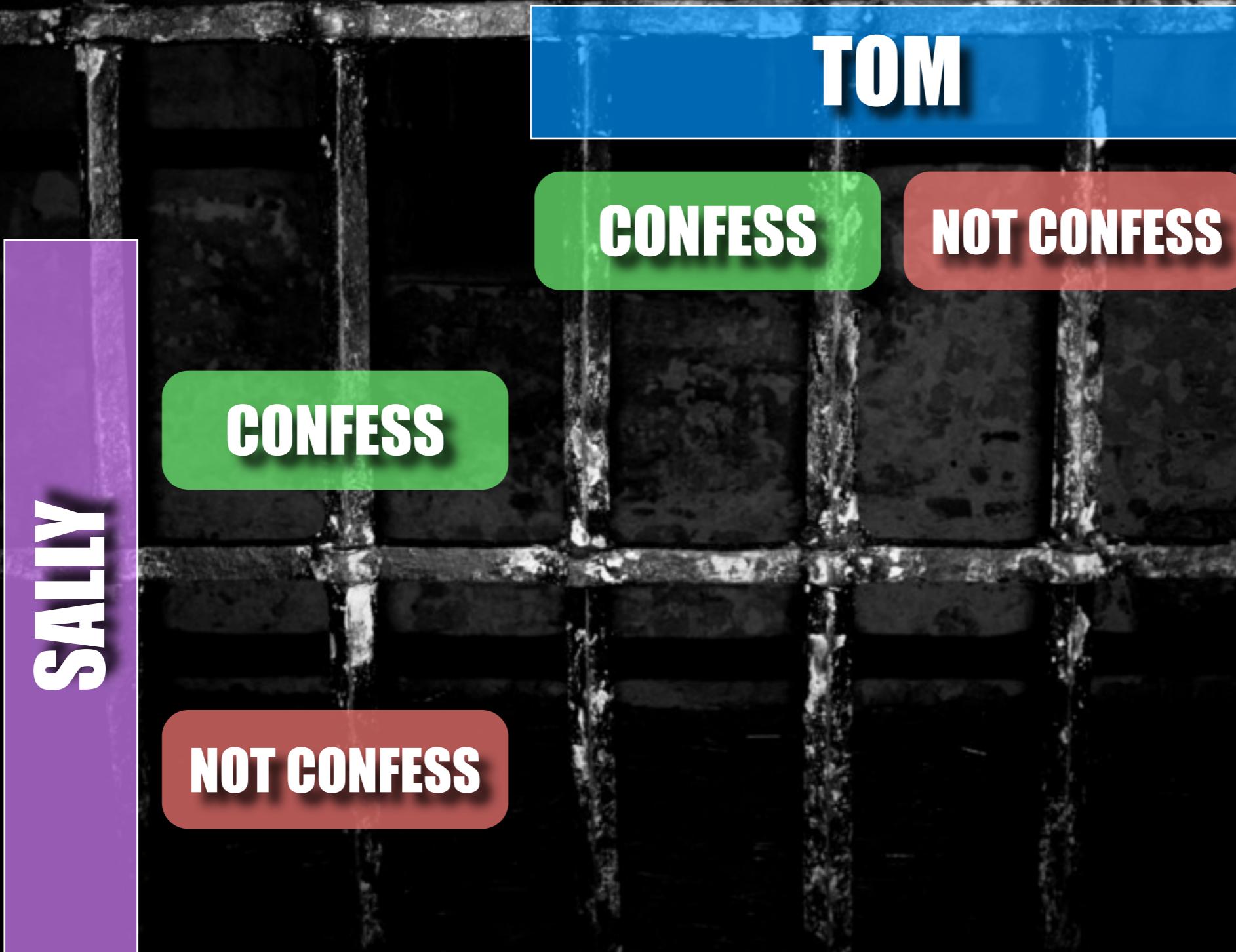
TOM

The prisoner's dilemma

SALLY

TOM

The prisoner's dilemma



The prisoner's dilemma



The prisoner's dilemma



The prisoner's dilemma



The prisoner's dilemma



The prisoner's dilemma



Contrasting Goals



Contrasting Goals

Pursuing high cohesion and low
coupling in object oriented
systems



Contrasting Goals

**Pursuing high cohesion and low
coupling in object oriented
systems**

**Bug triageing,
Test Case generation, ...**

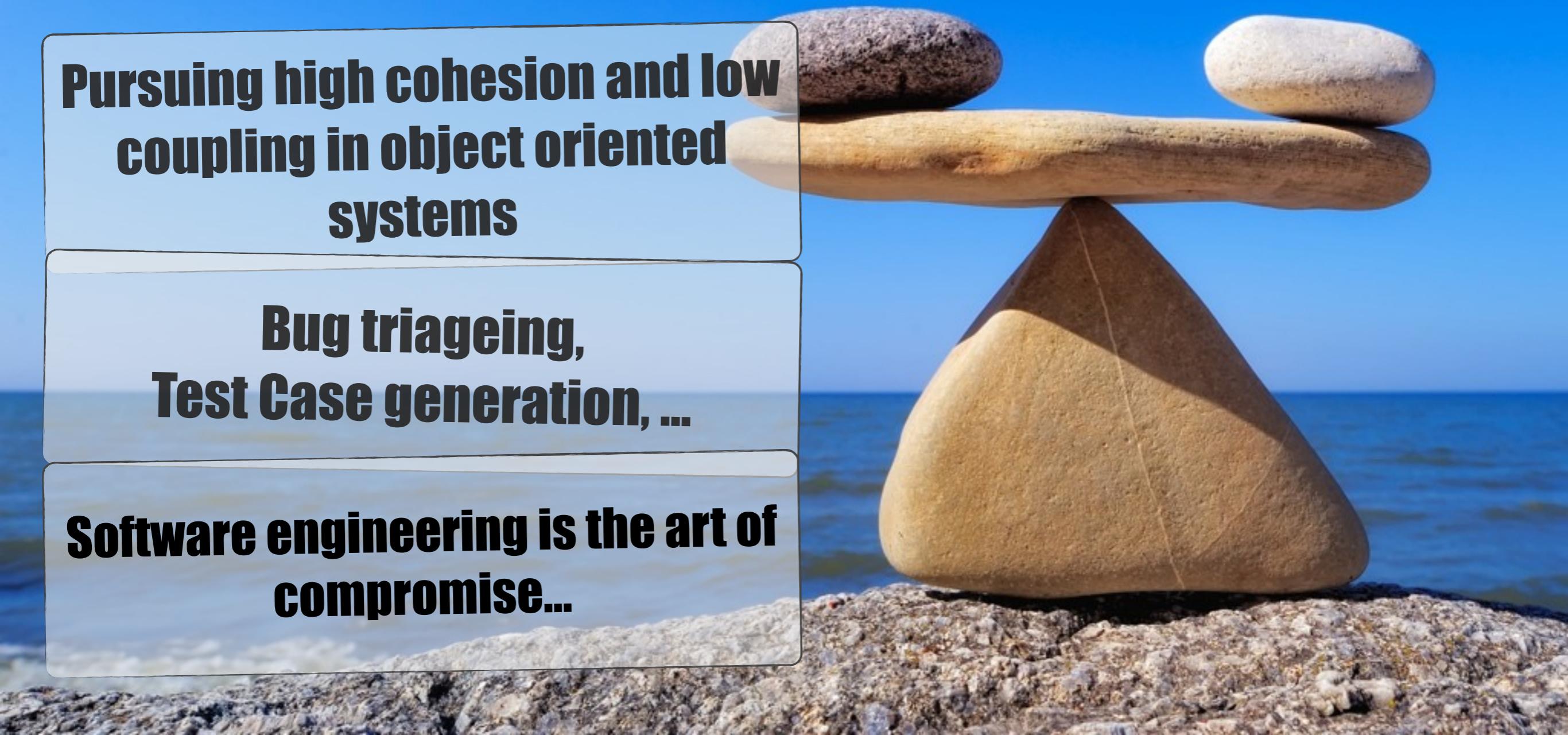


Contrasting Goals

Pursuing high cohesion and low coupling in object oriented systems

Bug triageing,
Test Case generation, ...

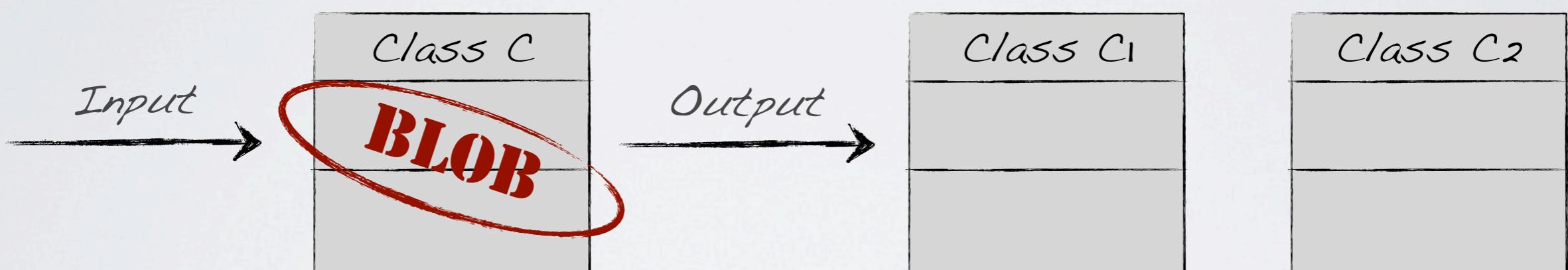
Software engineering is the art of compromise...



Software refactoring



Extract Class Refactoring



Splitting a class with many responsibilities into different classes



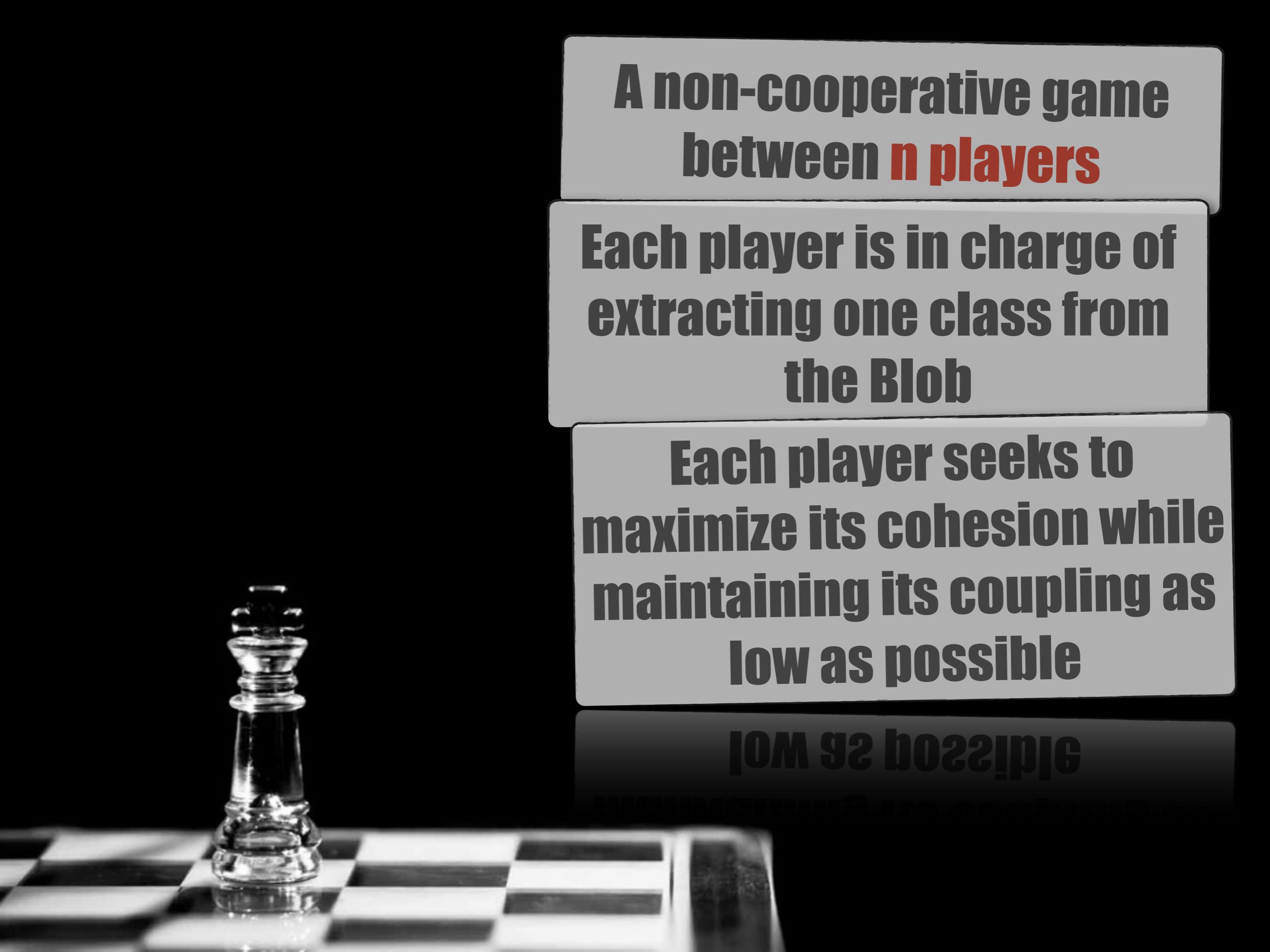
A non-cooperative game
between **n** players



A non-cooperative game
between **n** players

Each player is in charge of
extracting one class from
the Blob





A non-cooperative game
between **n** players

Each player is in charge of
extracting one class from
the Blob

Each player seeks to
maximize its cohesion while
maintaining its coupling as
low as possible

It's as possible

2-players game

		TOM m_5			
		m_2	m_3	m_4	N
m_1		-1.00, -1.00	0.49, 0.22	0.70, 0.80	0.70, 0.50
SALLY	m_2	-0.49, -0.24	-1.00, -1.00	0.21, 0.58	0.21, 0.28
	m_3	-0.70, -0.80	-0.21, -0.58	-1.00, -1.00	0.00, -0.30
	m_4	-0.20, 0.00	0.29, 0.22	0.50, -0.80	-1.00, -1.00
	N				

2-players game

		TOM m ₅			
		m ₂	m ₃	m ₄	N
SALLY m ₁		-1.00, -1.00	0.49, 0.22	0.70, 0.80	0.70, 0.50
m ₂		-0.49, -0.24	-1.00, -1.00	0.21, 0.58	0.21, 0.28
m ₃		-0.70, -0.80	-0.21, -0.58	-1.00, -1.00	0.00, -0.30
m ₄		-0.20, 0.00	0.29, 0.22	0.50, -0.80	-1.00, -1.00
N					

2-players game

		TOM m_5			
		m_2	m_3	m_4	N
m_1		-1.00, -1.00	0.49, 0.22	0.70, 0.80	0.70, 0.50
SALLY	m_2	-0.49, -0.24	-1.00, -1.00	0.21, 0.58	0.21, 0.28
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	m_4	-0.20, 0.00	0.29, 0.22	0.50, -0.80	-1.00, -1.00
	N				

2-players game

		TOM				
		m_5	m_2	m_3	m_4	
		m_2	-1.00, -1.00	0.49, 0.22	0.70, 0.80	0.70, 0.50
		m_3	-0.49, -0.24	-1.00, -1.00	0.21, 0.58	0.21, 0.28
		m_4	-0.70, -0.80	-0.21, -0.58	-1.00, -1.00	0.00, -0.30
SALLY		N	-0.20, 0.00	0.29, 0.22	0.50, -0.80	-1.00, -1.00

2-players game

		COHESION			
		m ₅	m ₂	m ₃	m ₄
TOM		-1.00, -1.00	0.49, 0.22	0.70, 0.80	0.70, 0.50
SALLY	m ₂	-0.49, -0.24	-1.00, -1.00	0.21, 0.58	0.21, 0.28
	m ₃	-0.70, -0.80	-0.21, -0.58	-1.00, -1.00	0.00, -0.30
	m ₄	-0.20, 0.00	0.29, 0.22	0.50, -0.80	-1.00, -1.00
	N	0.70 = sim(m ₁ , m ₂) - sim(m ₁ , m ₄)			

2-players game

		COHESION COUPLING			
		TOM	m ₅	0.70 = sim(m ₁ , m ₂) - sim(m ₁ , m ₄)	
		m ₂	m ₃	m ₄	N
SALLY	m ₂	-1.00, -1.00	0.49, 0.22	0.70, 0.80	0.70, 0.50
	m ₃	-0.49, -0.24	-1.00, -1.00	0.21, 0.58	0.21, 0.28
	m ₄	-0.70, -0.80	-0.21, -0.58	-1.00, -1.00	0.00, -0.30
	N	-0.20, 0.00	0.29, 0.22	0.50, -0.80	-1.00, -1.00

2-players game

		TOM m_5			
		m_2	m_3	m_4	N
m_1		-1.00, -1.00	0.49, 0.22	0.70, 0.80	0.70, 0.50
SALLY	m_2	-0.49, -0.24	-1.00, -1.00	0.21, 0.58	0.21, 0.28
	m_3	-0.70, -0.80	-0.21, -0.58	-1.00, -1.00	0.00, -0.30
	m_4	-0.20, 0.00	0.29, 0.22	0.50, -0.80	-1.00, -1.00
	N				

2-players game

		TOM m_5			
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m_4		-0.20, 0.00	0.29, 0.22	0.50, -0.80	-1.00, -1.00
N					

2-players game

		TOM			
		m ₅	m ₄	m ₃	N
		m ₂		m ₃	
SALLY	m ₂	-1.00, -1.00	0.49, 0.22	0.70, 0.80	0.70, 0.50
	m ₃	-0.49, -0.24	-1.00, -1.00	0.21, 0.58	0.21, 0.28
	m ₄	-0.70, -0.80	-0.21, -0.58	-1.00, -1.00	0.00, -0.30
	N	-0.20, 0.00	0.29, 0.22	0.50, -0.80	-1.00, -1.00

2-players game

		TOM			
		m ₅	m ₄	m ₃	m ₂
		N	m ₄	m ₃	m ₂
SALLY	m ₂	-1.00, -1.00	0.49, 0.22	0.70, 0.80	0.70, 0.50
	m ₃	-0.49, -0.24	-1.00, -1.00	0.21, 0.58	0.19, 0.25
	m ₄	-0.70, -0.80	-0.21, -0.58	-1.00, -1.00	0.00, -0.30
	N	-0.20, 0.00	0.39, 0.32	0.50, -0.80	-1.00, -1.00

2-players game

		TOM			
		m ₅	m ₄	m ₃	m ₂
		N			
SALLY	m ₂	-1.00, -1.00	0.49, 0.22	0.70, 0.80	0.70, 0.50
	m ₃	-0.49, -0.24	-1.00, -1.00	0.21, 0.58	0.19, 0.25
	m ₄	-0.70, -0.80	-0.21, -0.58	-1.00, -1.00	0.00, -0.30
	N	-0.20, 0.00	0.39, 0.32	0.50, -0.80	-1.00, -1.00

2-players game

		TOM	m ₅	m ₄	m ₃	
		m ₂		m ₄		N
SALLY	m ₂	-1.00, -1.00	0.49, 0.22	0.70, 0.80	0.70, 0.50	
	m ₃	-0.49, -0.24	-1.00, -1.00	0.21, 0.58	0.19, 0.25	
	m ₄	-0.70, -0.80	-0.21, -0.58	-1.00, -1.00	0.00, -0.30	
	N	-0.20, 0.00	0.39, 0.32	0.50, -0.80	-1.00, -1.00	

2-players game

SALLY

m₂

m₁

TOM m₅ m₄ m₃

Study Design



Metric-based Evaluation





LCOM

+72%



LCOM

+72%

C3

+118%



LCOM

+72%

C3

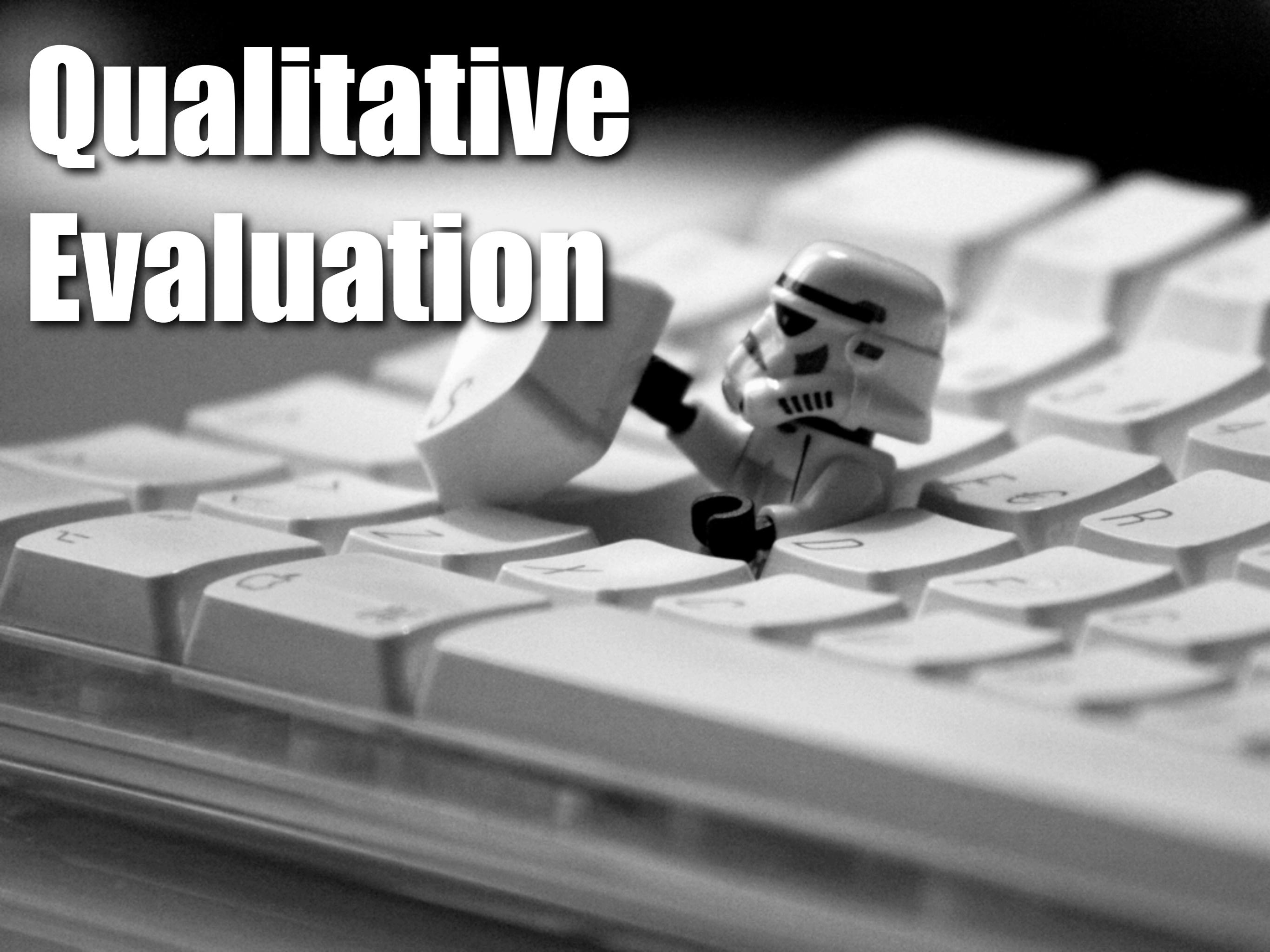
+118%

MPC

+1%



Qualitative Evaluation



Subjects

2 PhD and 6 Master students

Objects

The 7 Blobs of the metric evaluation

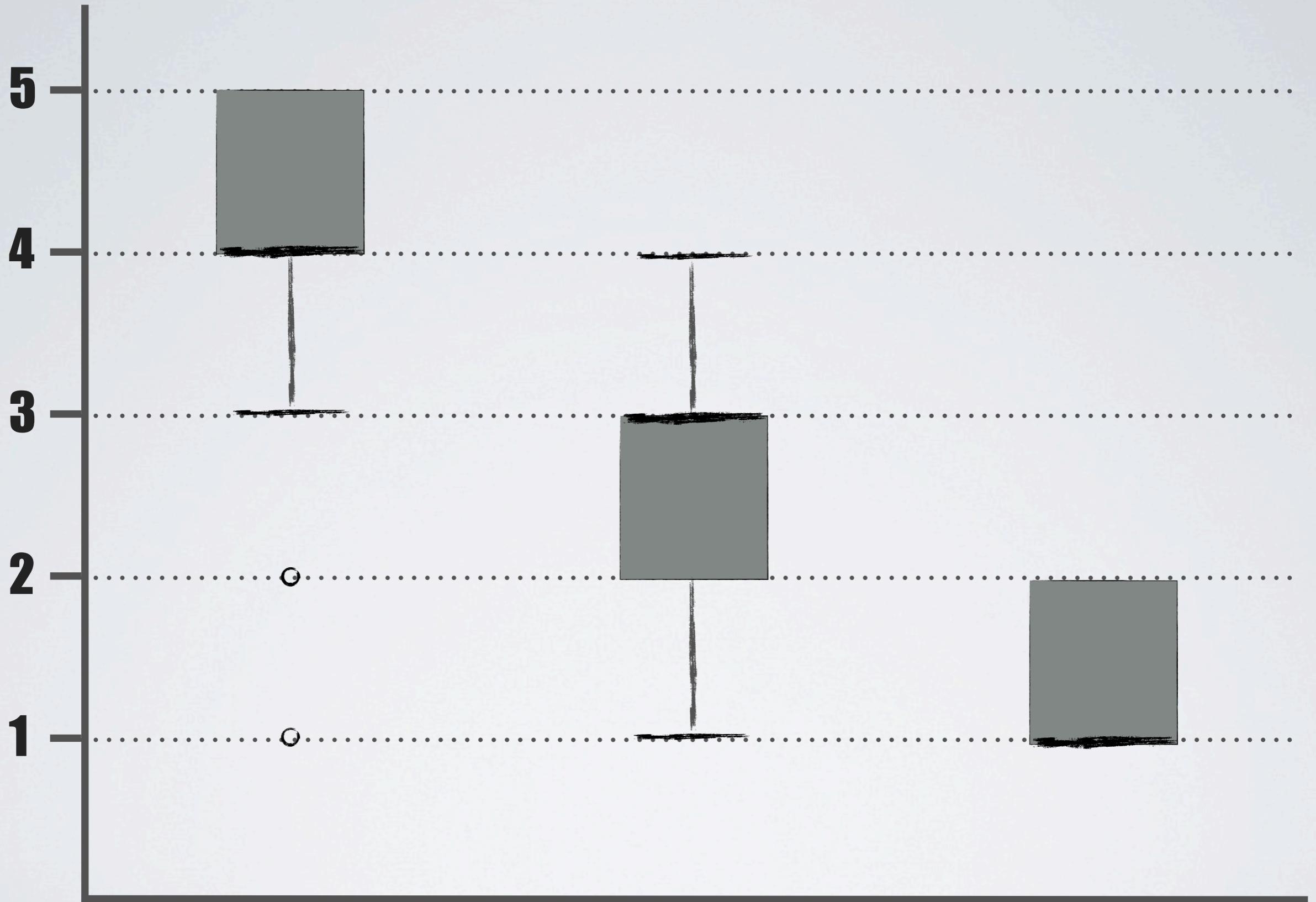
Baselines

We refactored the 7 Blobs using: our approach, k-means, and a random splitting.

What we asked

Agreement to the claim: “The proposed refactoring results in an appropriate division of responsibilities”

Five point Likert scale: “1: Strongly disagree; 2: Disagree; 3: Neutral; 4: Agree; 5: Fully agree”



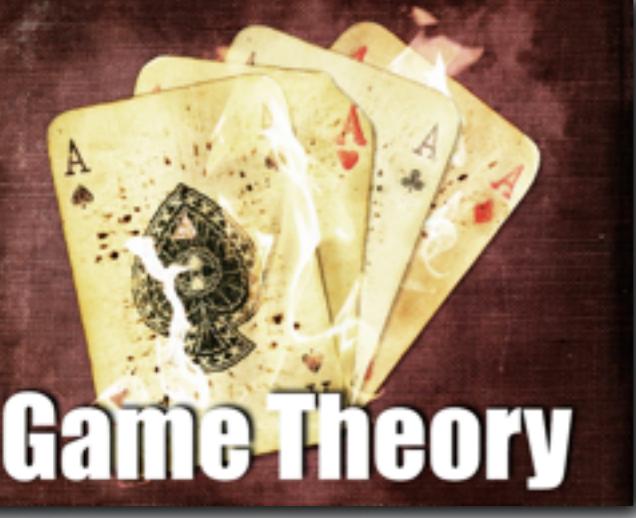
Game Theory

k-means

Random

Conclusion





Game Theory



Game Theory

Contrasting Goals

Pursuing high cohesion and low coupling in object oriented systems

Bug triage: assign bug fixing to the most expert developers without overload them

Software engineering is the art of compromise...



Game Theory



Contrasting Goals

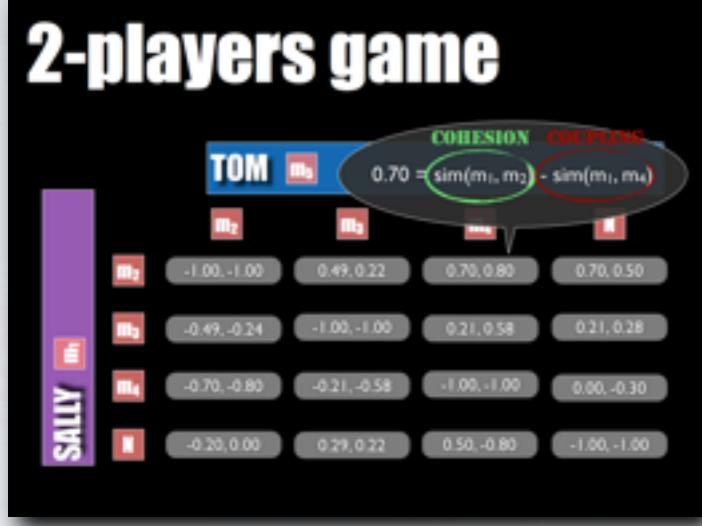
Pursuing high cohesion and low coupling in object oriented systems

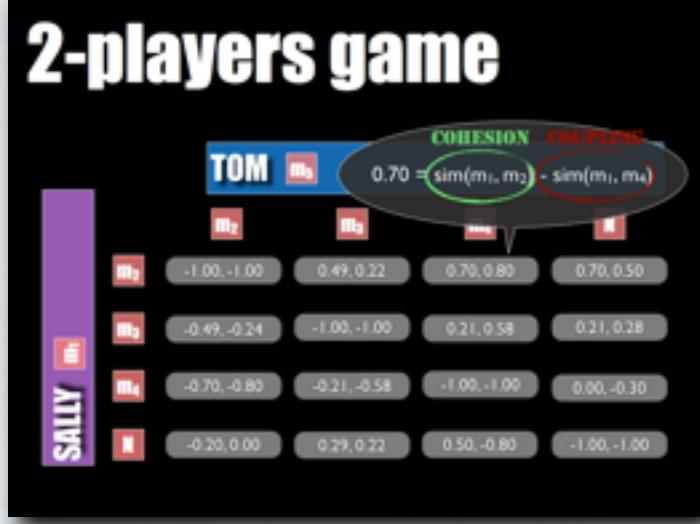
Bug triage: assign bug fixing to the most expert developers without overload them

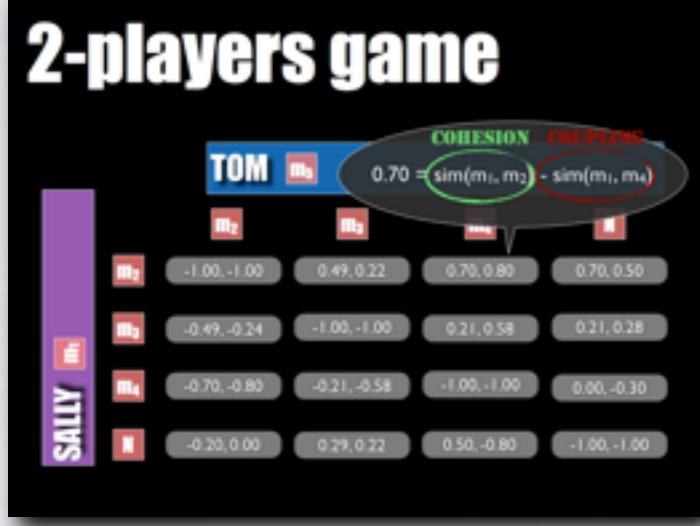
Software engineering is the art of compromise...

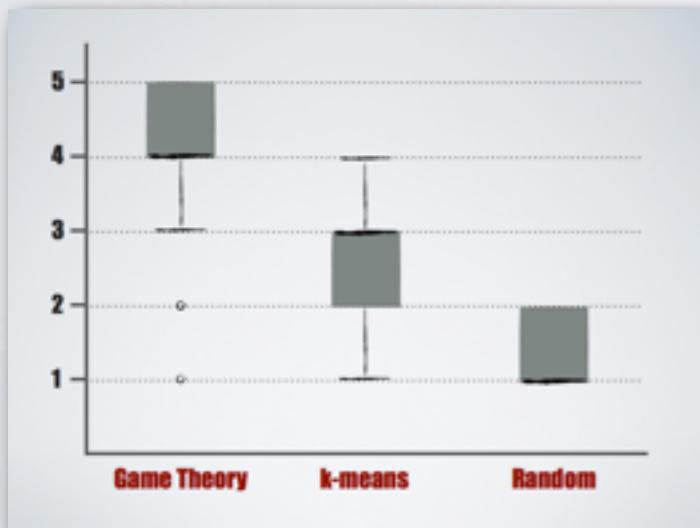
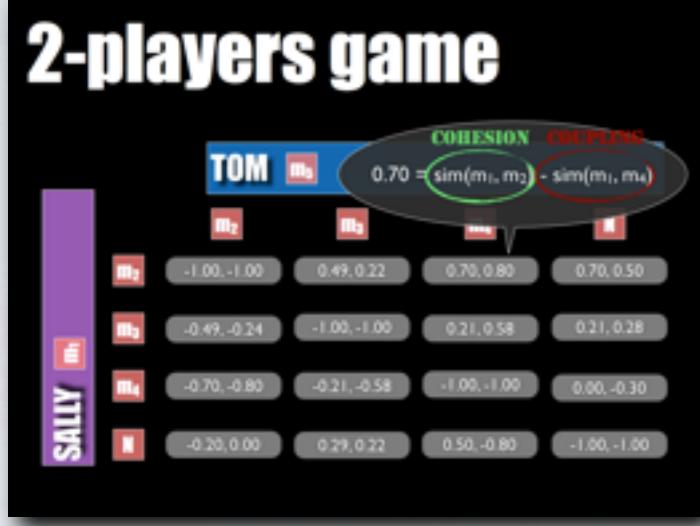
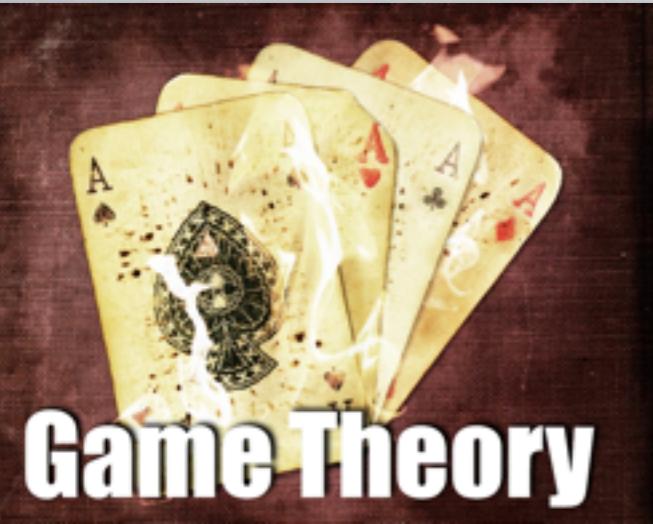
A photograph of several smooth, rounded stones balanced on top of each other in a cairn-like structure on a sandy beach with the ocean and sky in the background.

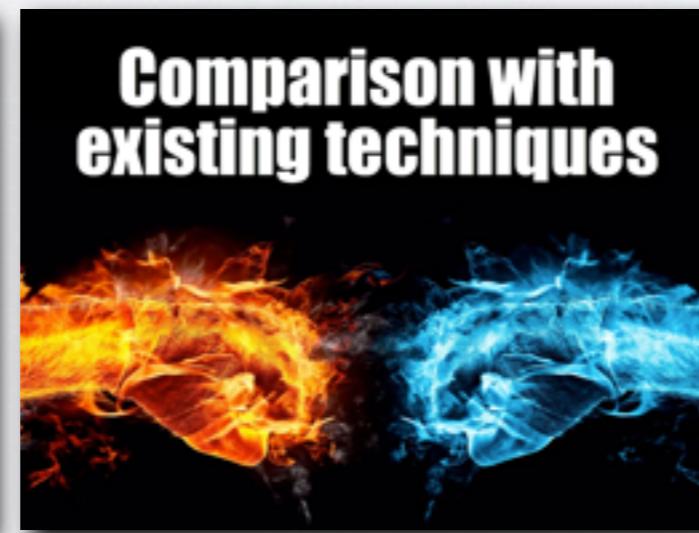
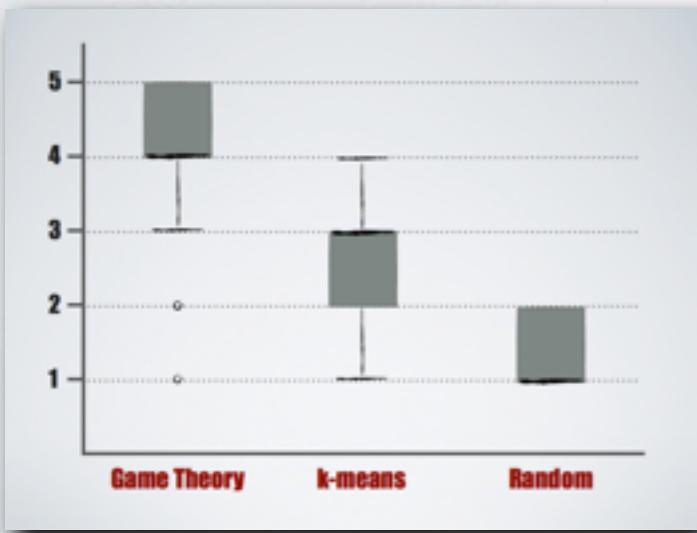
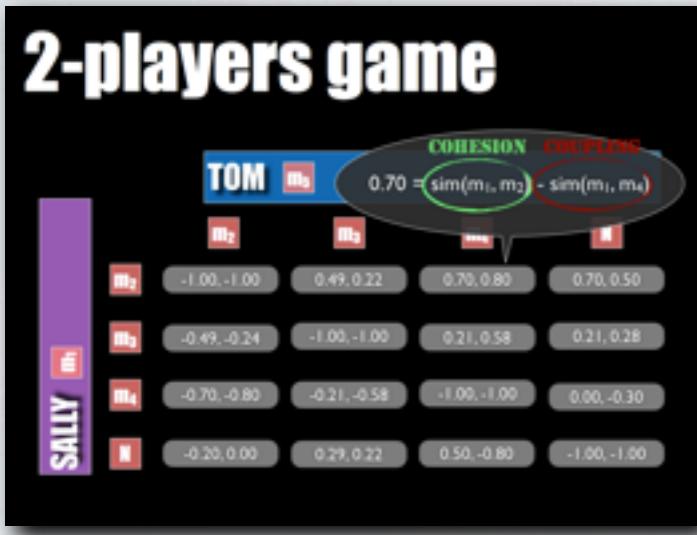
Software Refactoring

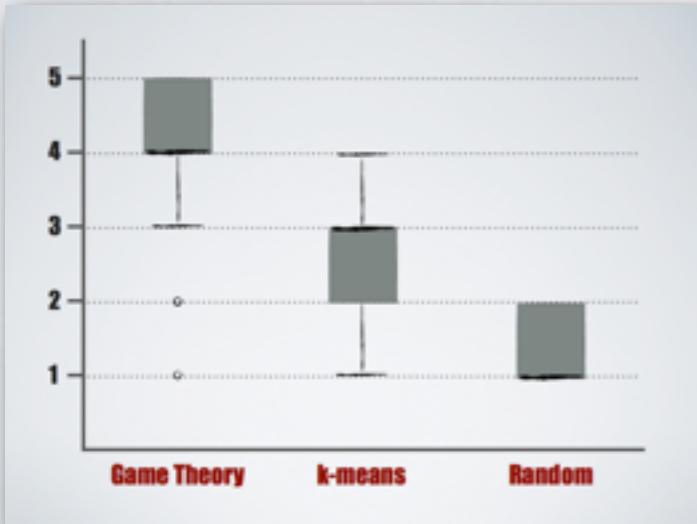
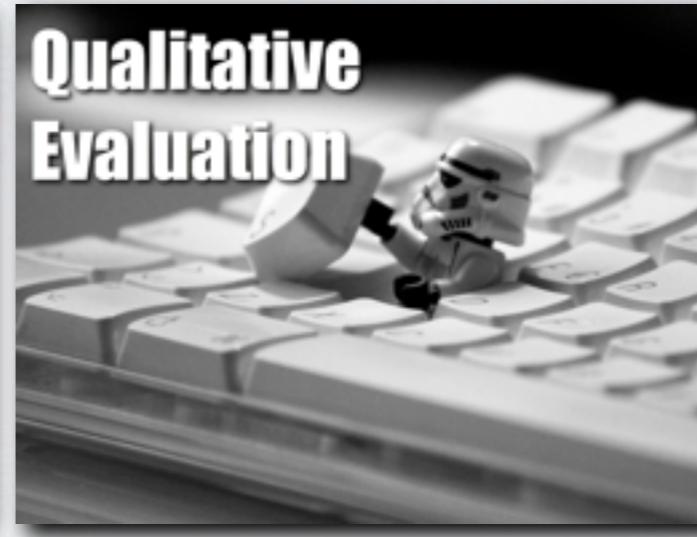
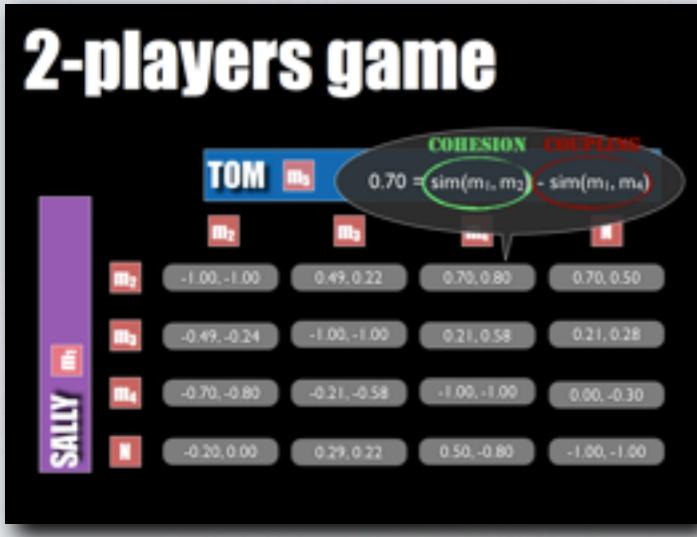




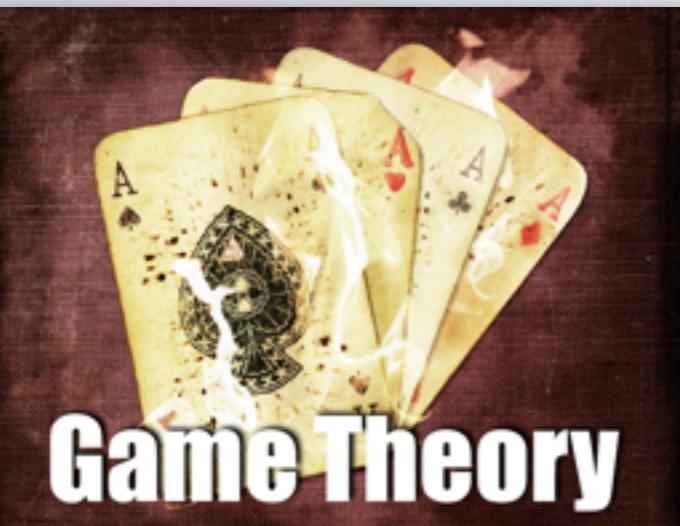








Game Theory



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Software engineering is the art of compromise...



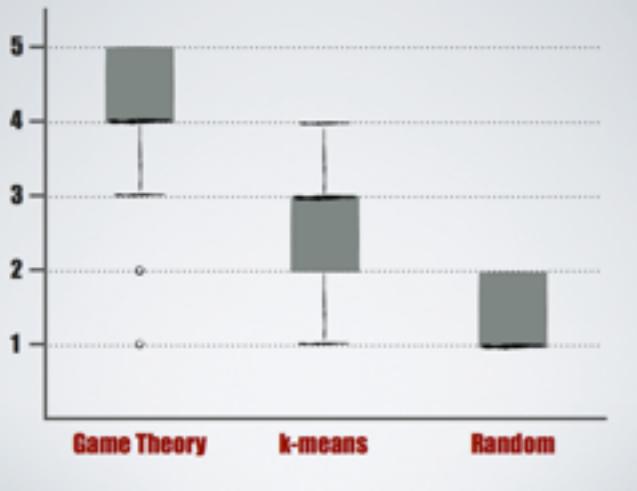
Software Refactoring



2-players game



Qualitative Evaluation



Comparison with existing techniques

