

OpenConflict

Preventing Map Hack in online games

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Welcome to the real world

#kartograph / @elie



273 Millions games sold in
2009



Strategy account for **35%** of
the games sold in **2009**



TG삼보 인텔
STAR CRAFT
OPEN

| GSL Pre-Season |

TG삼보-인텔 STAR CRAFT II OPEN SEASON 1

우승

₩ 100,000,000

GOMTV

TG삼보

intel

BILZARD
ENTERTAINMENT



TG삼보 인텔
STARCRAFT
OPEN

| GSL Pre-Season |
TG삼보-인텔 STARCRAFT II OPEN SEASON1

MSL

MSL
TESLA
ITC
@mb

우승

₩ 100,000,000

GOMTV

TG삼보

intel

BIZZARD
ENTERTAINMENT

Cash prize up to 200,000\$

Outline

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- **Background**

Outline

- Background
- Memory based map-hack with Kartograph

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- Memory based map-hack with Kartograph
- Defending against map-hack

Outline

- Background
- Memory based map-hack with Kartograph
- Defending against map-hack
- Starcraft 2 case study

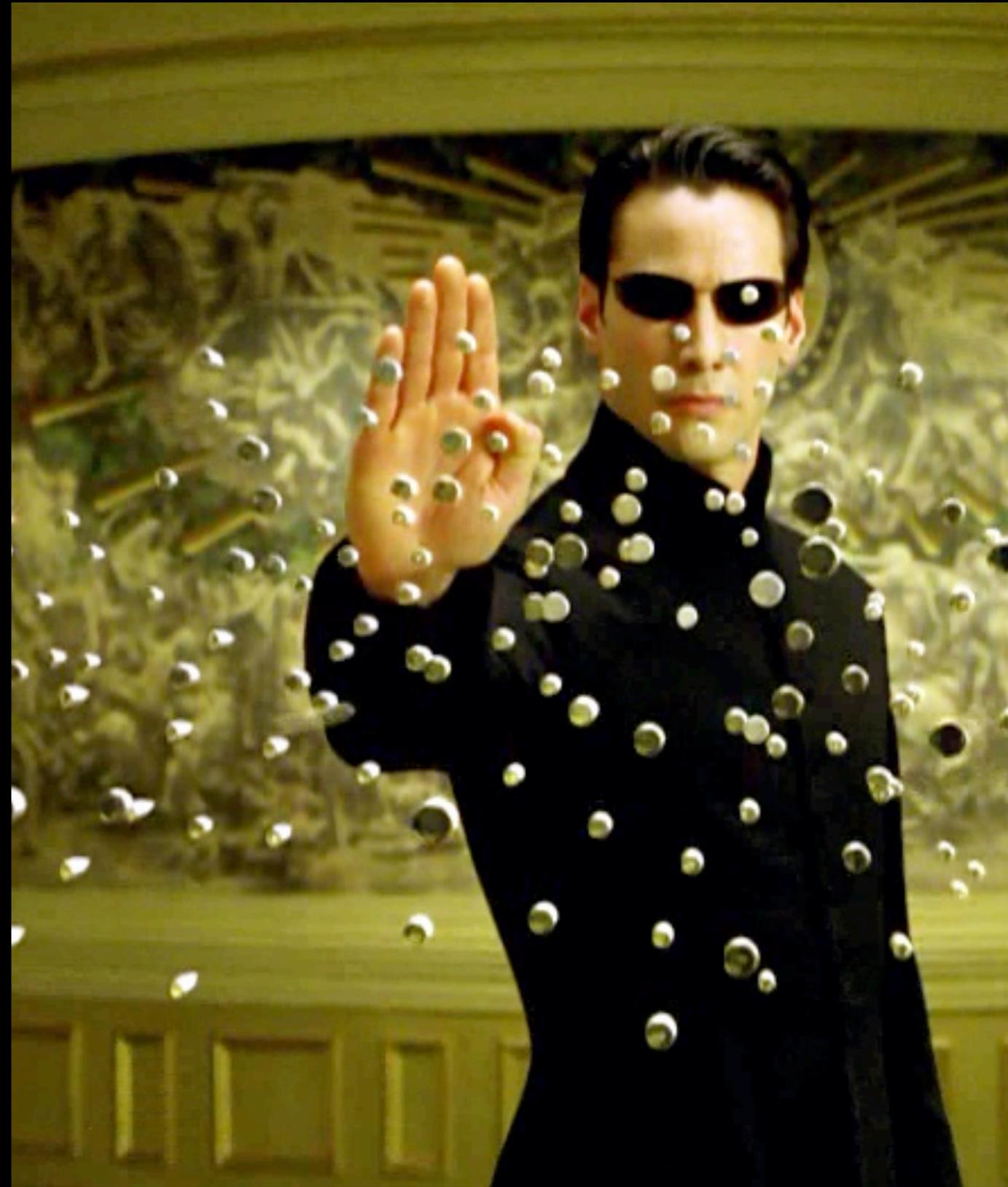
Outline

- Background
- Memory based map-hack with Kartograph
- Defending against map-hack
- Starcraft 2 case study
- Open conflict benchmark

Background

supernatural powers !

- Learn kungfu
- Infinite money
- Xray vision
- god mode



Memory based attack



Memory

Memory based attack



Memory

Modification

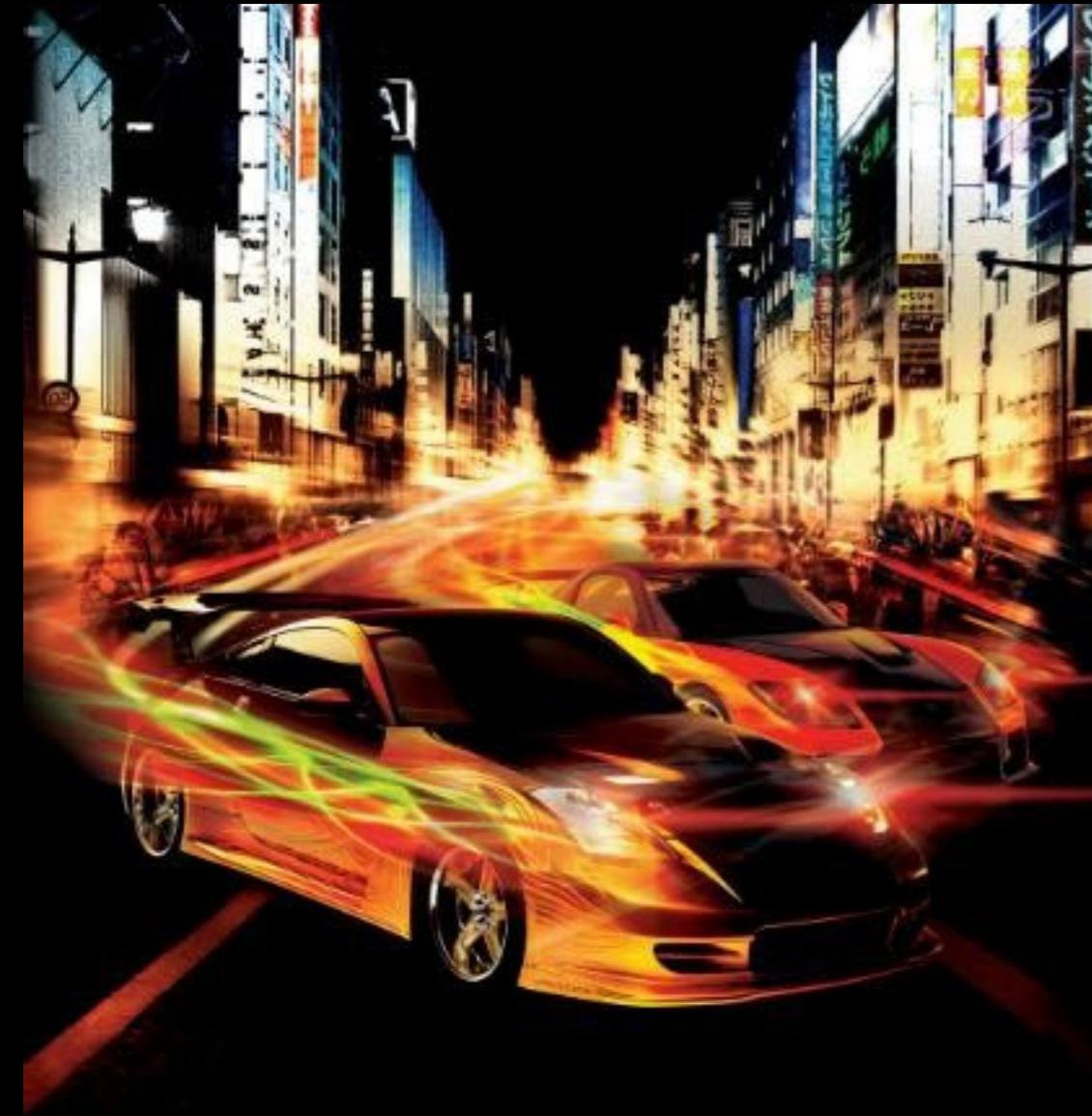
Memory based attack



Memory

Modification

Benefits (fast and furious)



- Generic
- Fast
- Invisible

Drawbacks: Needle in a Haystack



Game memory



Structures





Tankbuster
\$ 300 ⌚ 0:05
Anti-Armor
Steely-cold warriors whose personal plasma-cutter cannons can slice through enemy armor.

Instant Dojo

--	--

Navigation buttons: left arrow, right arrow, and a question mark icon.

Zoom level: 1x, 12x, 13x

Zoom indicator: 1



Resources

Tankbuster
\$ 300 ⌚ 0:05
Anti-Armor
Steely-cold warriors whose personal plasma-cutter cannons can slice through enemy armor.

Instant Dojo

--	--

1
11x 12x 13x



Resources

Tankbuster
\$ 300 ⌚ 0:05
Anti-Armor
Steely-cold warriors whose personal plasma-cutter cannons can slice through enemy armor.

Instant Dojo

--	--

4650

1

--	--	--

Building



The minimap shows the current game area with a yellow box highlighting the Tankbuster's location. Below the map, the resource panel shows 4650 credits and various icons for buildings and units.

Tankbuster
\$ 300 ⌚ 0:05
Anti-Armor
Steely-cold warriors whose personal plasma-cutter cannons can slice through enemy armor.

The unit selection menu displays various units available to the player, with the Tankbuster unit highlighted in yellow.

The Instant Dojo panel shows the Tankbuster building icon and a progress bar, indicating that the building is being constructed.

The zoom and camera controls panel shows a zoom level of 1x and a camera movement bar.



Units →

Tankbuster
\$ 300 ⌚ 0:05
Anti-Armor
Steely-cold warriors whose personal plasma-cutter cannons can slice through enemy armor.

Instant Dojo

--	--

Navigation buttons: left arrow, right arrow, and a question mark icon.

1

11x 12x 13x

Minimap →

The minimap shows a top-down view of the game map with a yellow box highlighting the current camera position. Below the map is a resource panel with icons for a wrench, a dollar sign, a gear, and a shield, followed by the number 4650. Below that are icons for a mail envelope, a house, a shield, a robot, a red house, a plane, and a ship.

Tankbuster
\$ 300 ⌚ 0:05
Anti-Armor
Steely-cold warriors whose personal plasma-cutter cannons can slice through enemy armor.

A grid of unit selection icons. The first row contains three icons: a satellite, a warrior, and a warrior. The second row contains three icons: a warrior, a warrior, and a warrior. The third row contains three icons: a warrior, a robot, and a robot.

The Instant Dojo panel shows a robot icon and a building icon. Below the icons are several smaller icons, including a question mark.

A zoom control panel with a circular dial showing the number 1, a horizontal bar with zoom levels 11x, 12x, and 13x, and a camera icon.



Minimap showing the current game area with a yellow box highlighting the Tankbuster's location. Below the minimap are icons for tools, money, and a resource count of 4650. A row of icons for buildings and units is also present.

Tankbuster
\$ 300 ⌚ 0:05
Anti-Armor
Steely-cold warriors whose personal plasma-cutter cannons can slice through enemy armor.

A grid of unit selection icons. The Tankbuster icon is highlighted in yellow. Other icons include various Zerg and Protoss units.

Instant Dojo
A menu for the Instant Dojo feature, showing a Tankbuster icon and a production building icon. Below are several smaller icons for different actions.

Zoom and camera controls including a circular zoom dial set to 1x, a zoom slider with 11x, 12x, and 13x markers, and a camera movement pad.

Menu [F10]

Message Log [F11]

Help [F12]

603 0 01/27

Production [C]



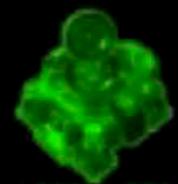
SPeCiALIST

psystarcraft

Everyone [L]



Orbital Command



1500 / 1500
14 / 200

Training

2 3 4 5



How to cheat at a RTS ?

How to cheat at a RTS ?



Resources

How to cheat at a RTS ?



Resources



units

How to cheat at a RTS ?



Resources



units



map

What is a map hack ?



What is a map hack ?





There is no spoon

Defeating security via obscurity

- Find the information **hidden** by the game
- Understand the data structures
- Abuse this knowledge



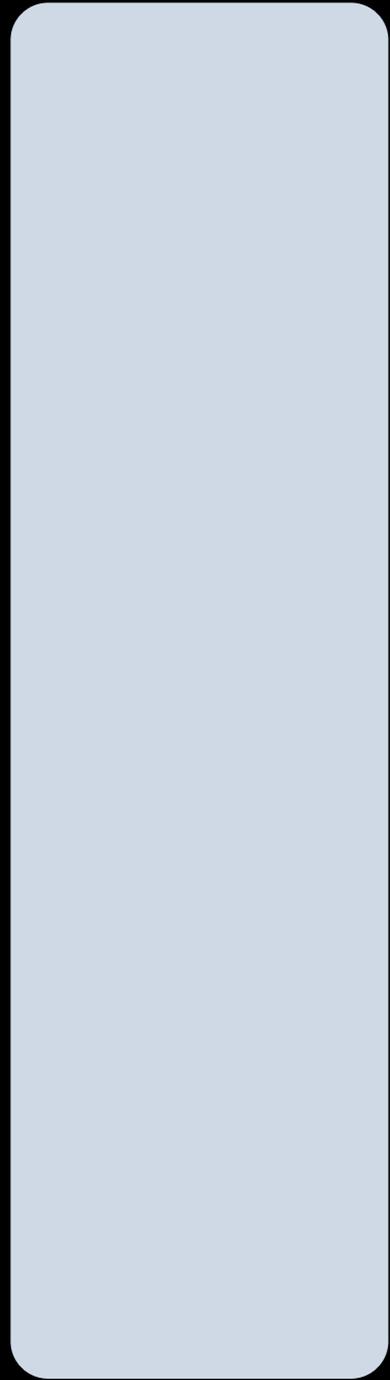
Kartograph

What is Kartograph ?

- Memory analysis techniques
- Visualization techniques

How Kartograph works ?

How Kartograph works ?



How Kartograph works ?



Reduce
haystack

How Kartograph works ?



Reduce
haystack

Find

How Kartograph works ?



Reduce
haystack

Find

Understand

How Kartograph works ?



Reduce
haystack

Find

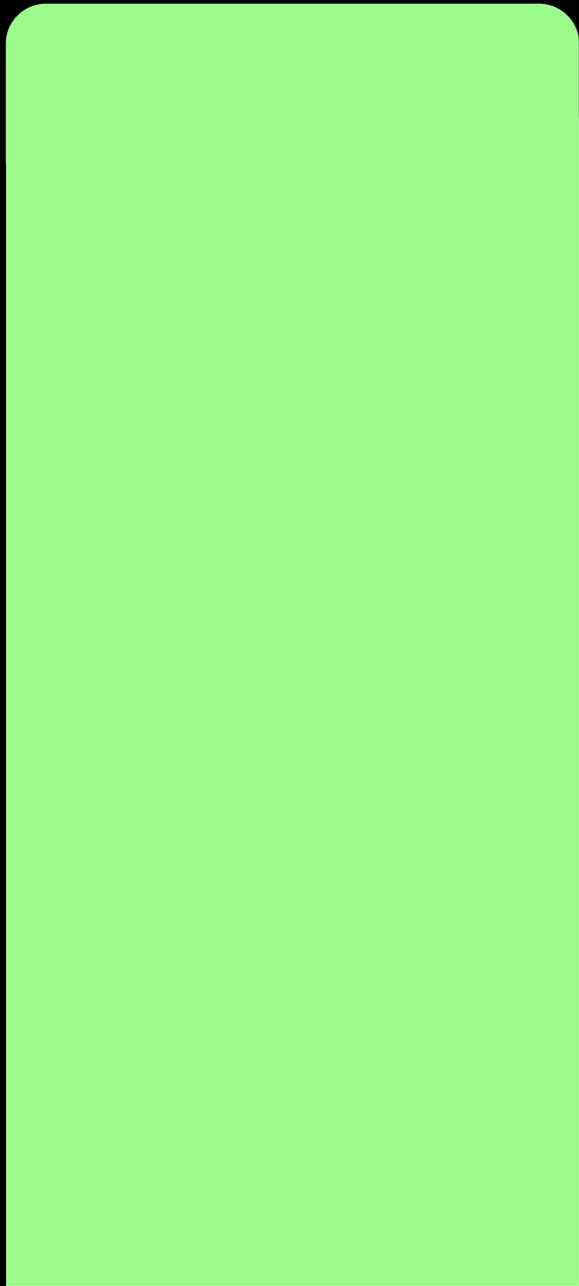
Understand

Rewrite

Acquiring game memory

Game
memory

Acquiring game memory



Reducing memory

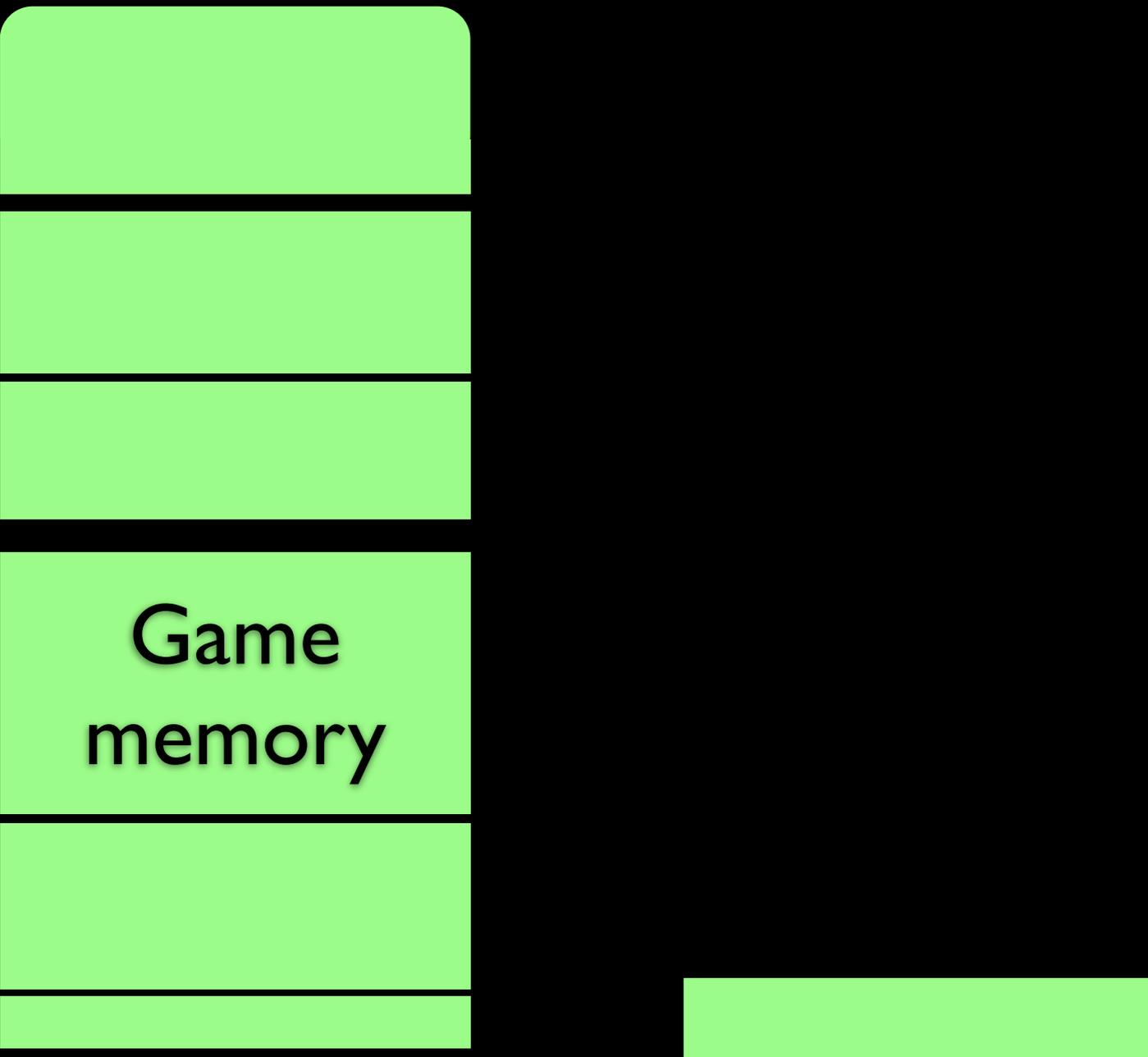
**Game
memory**

Reducing memory

Game
memory

Step 1 **play**

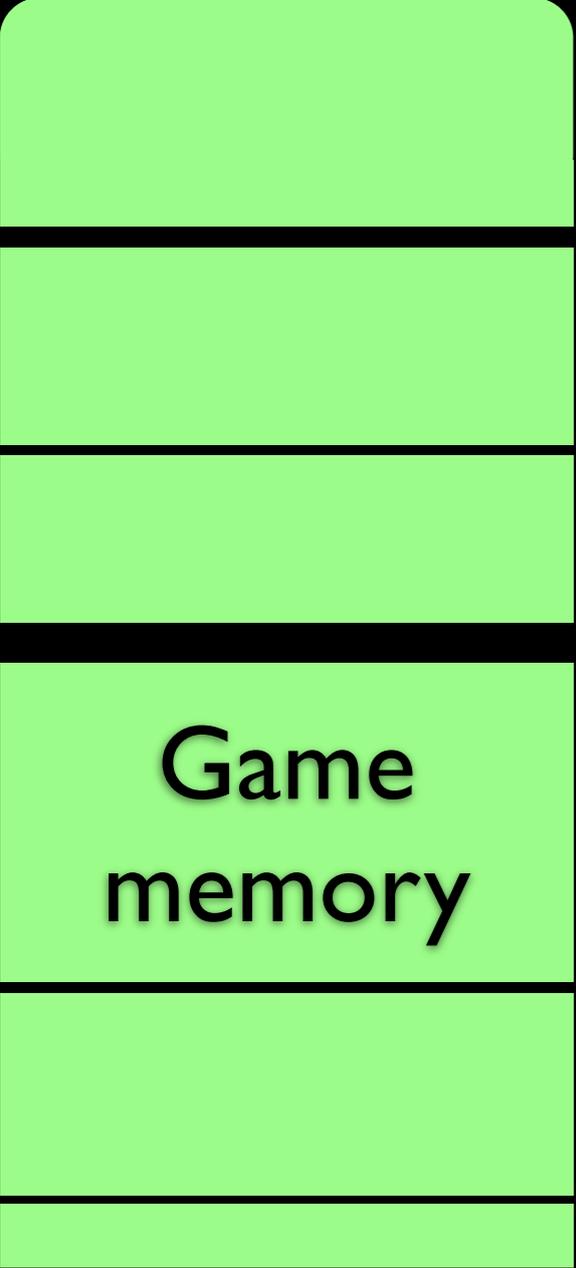
Reducing memory



Game
memory

Step 1 **play**

Reducing memory



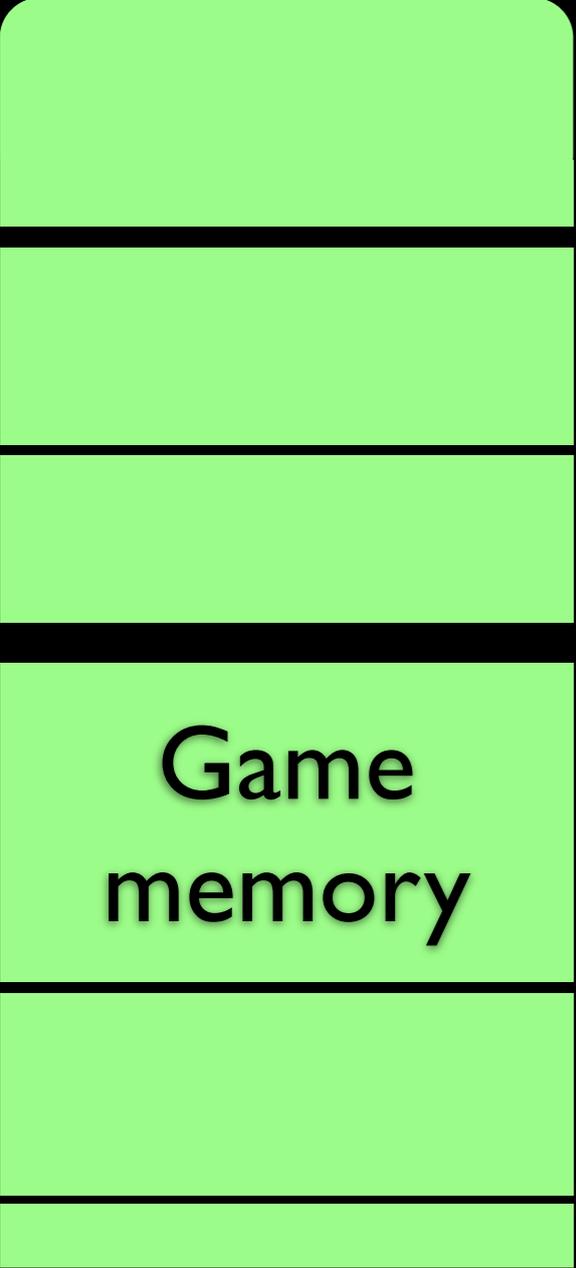
Game
memory



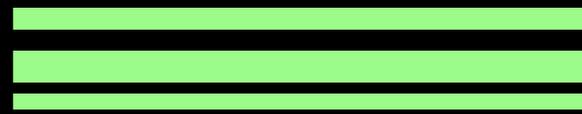
Step 1 **play**

Step 2 **discover**

Reducing memory



Game
memory

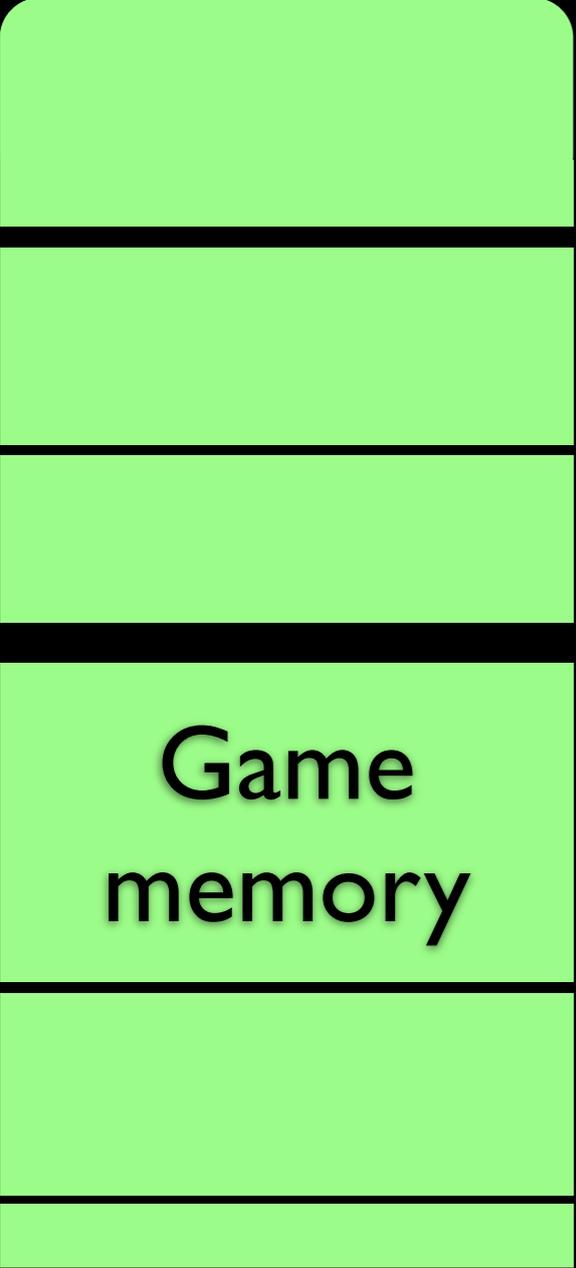


Step 1 **play**

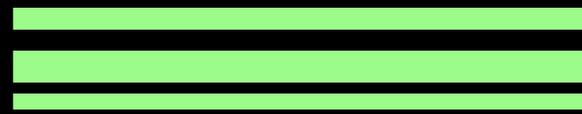


Step 2 **discover**

Reducing memory



Game
memory



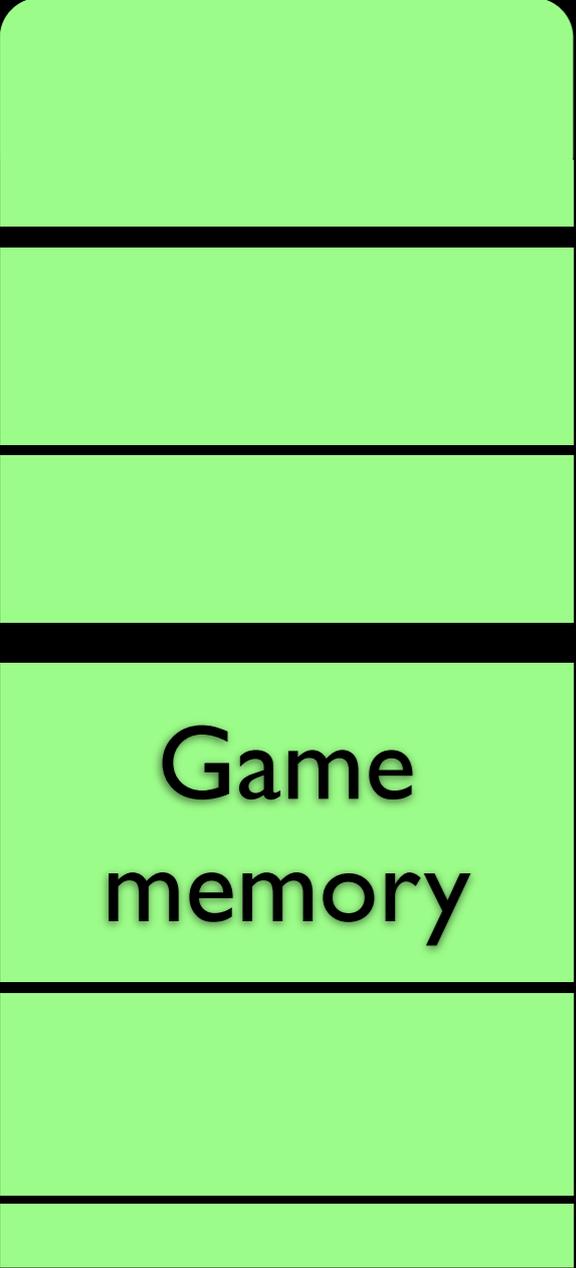
Step 1 **play**



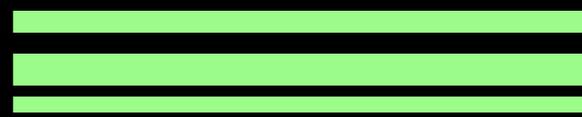
Step 2 **discover**

Step 3 **play**

Reducing memory



Game
memory



Step 1 **play**



Step 2 **discover**



Step 3 **play**

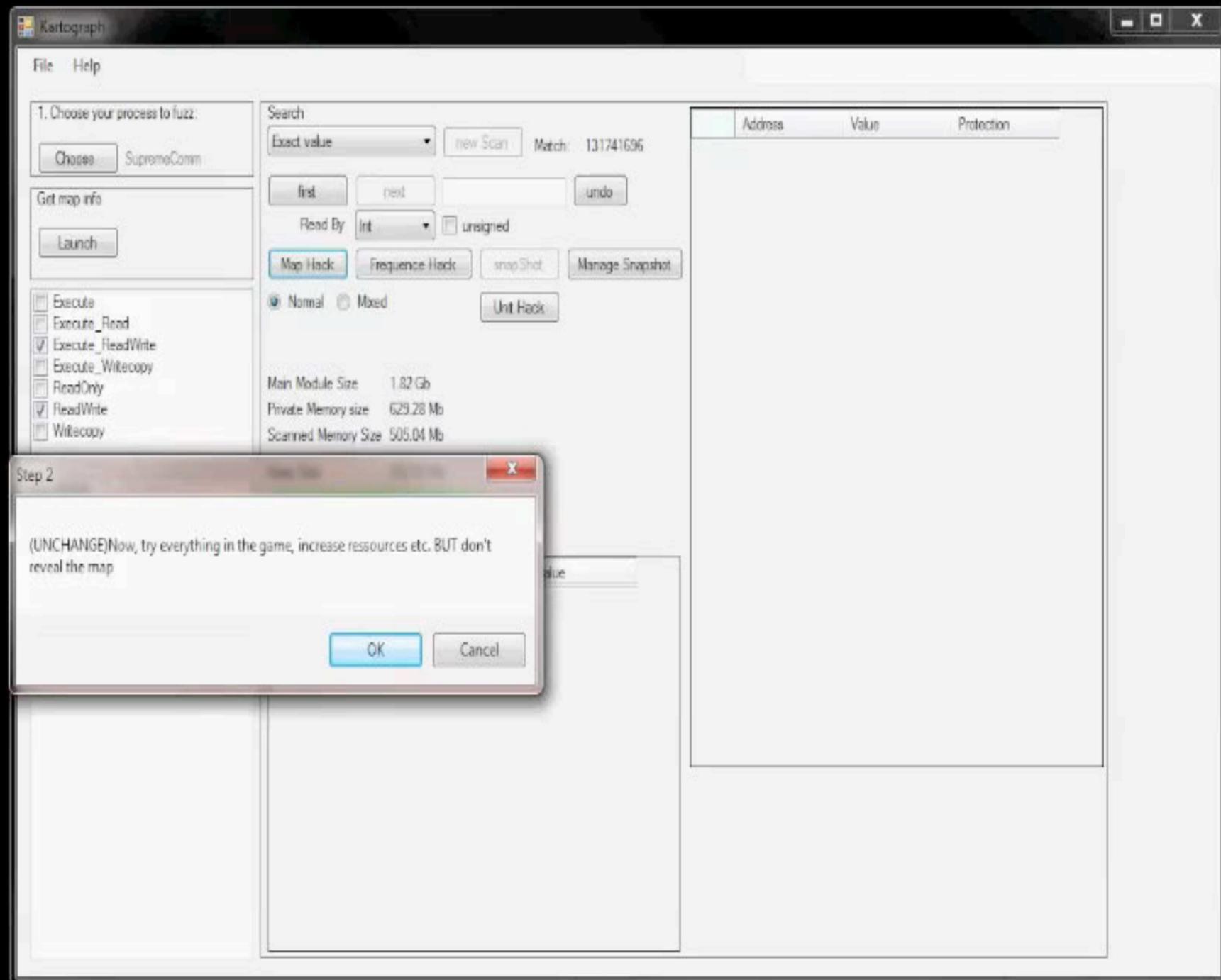
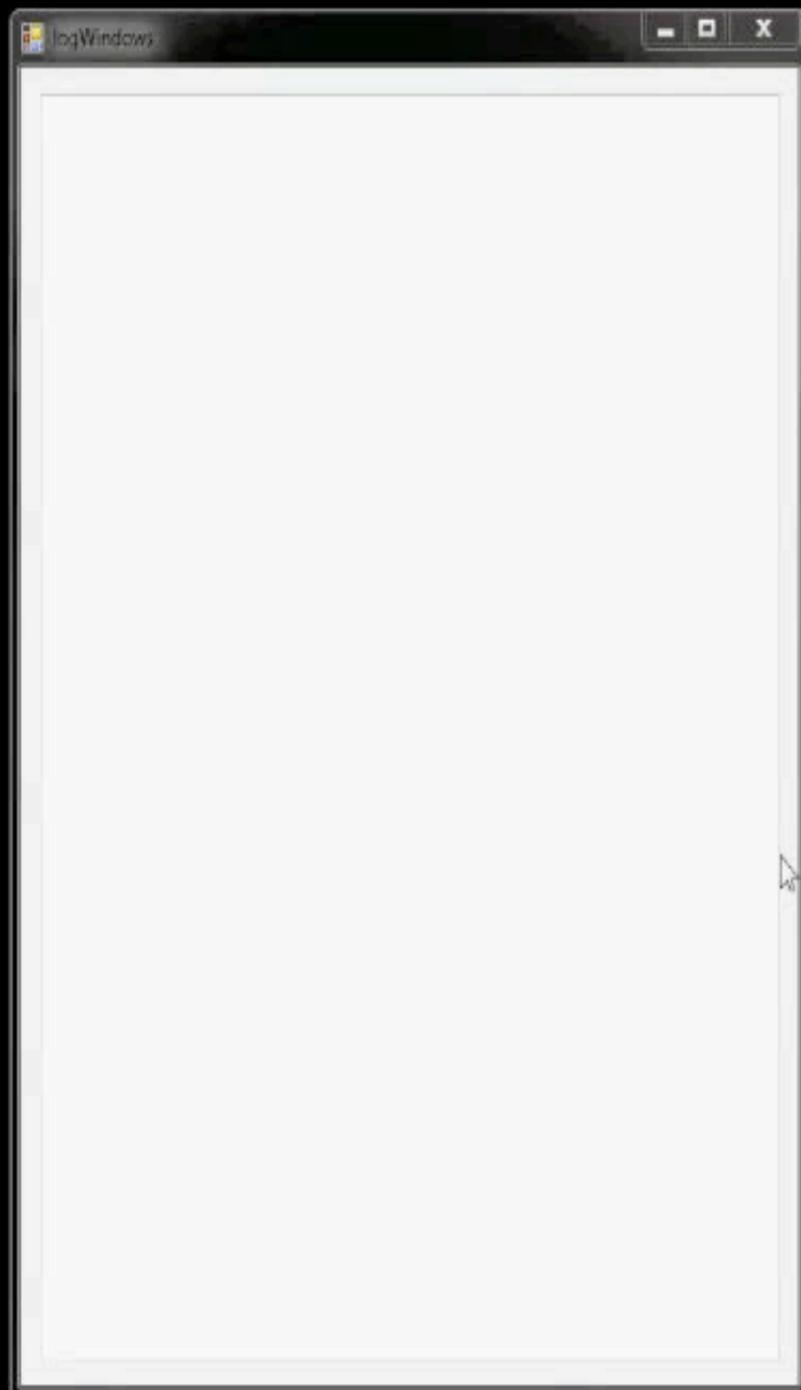
Reducing memory



Acquiring the game's memory

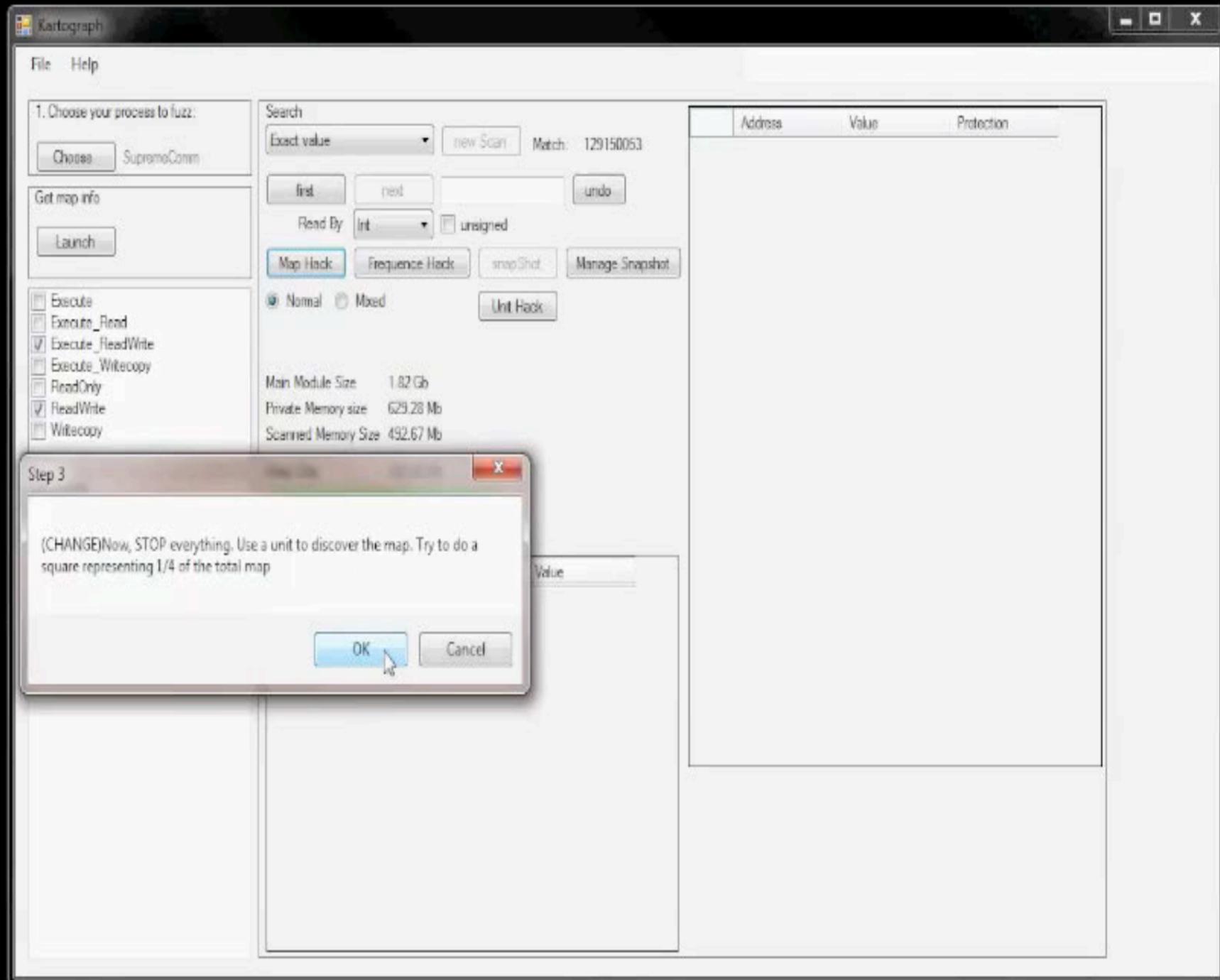
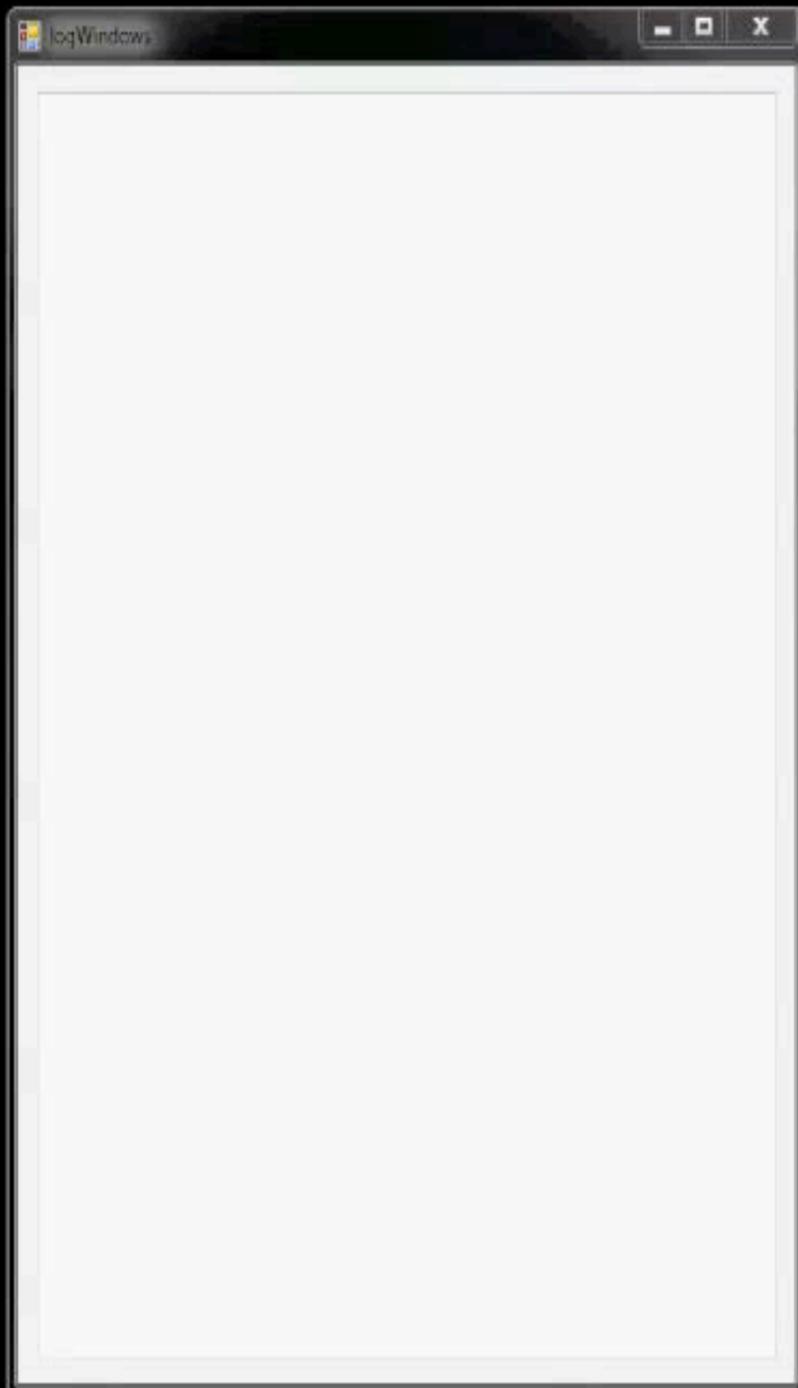
Step 1

Removing unrelated
memory



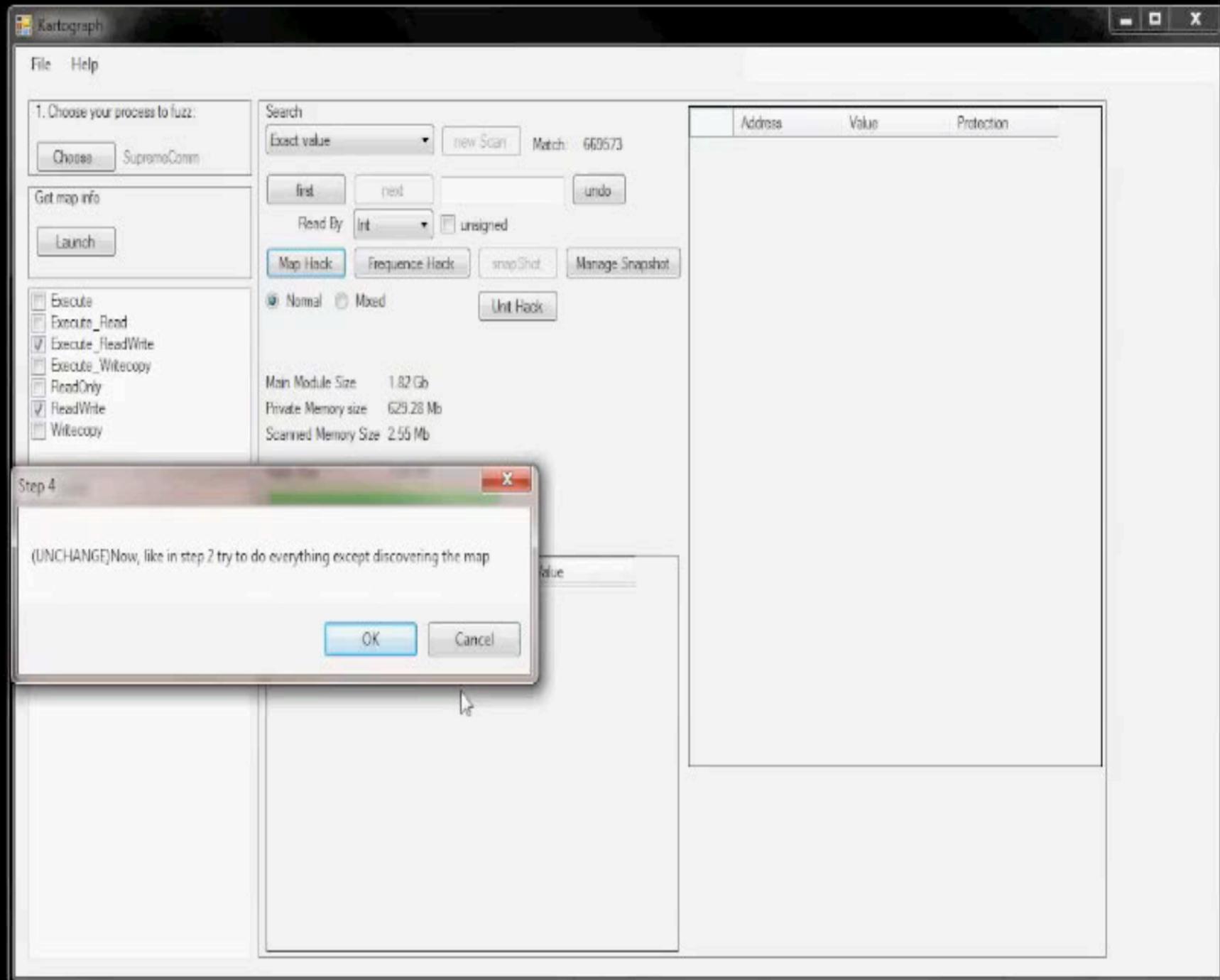
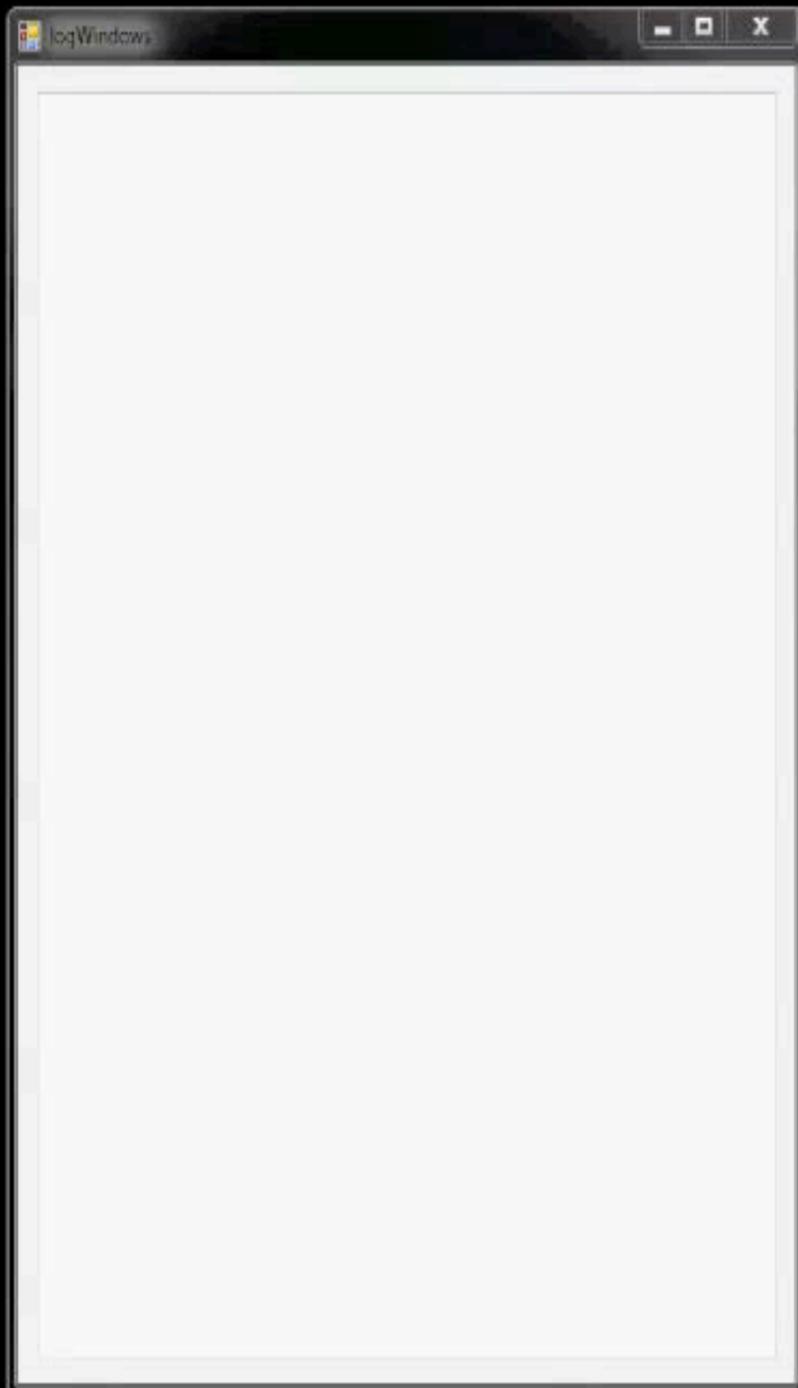
Step 2

Discovering the map and
keeping relevant memory

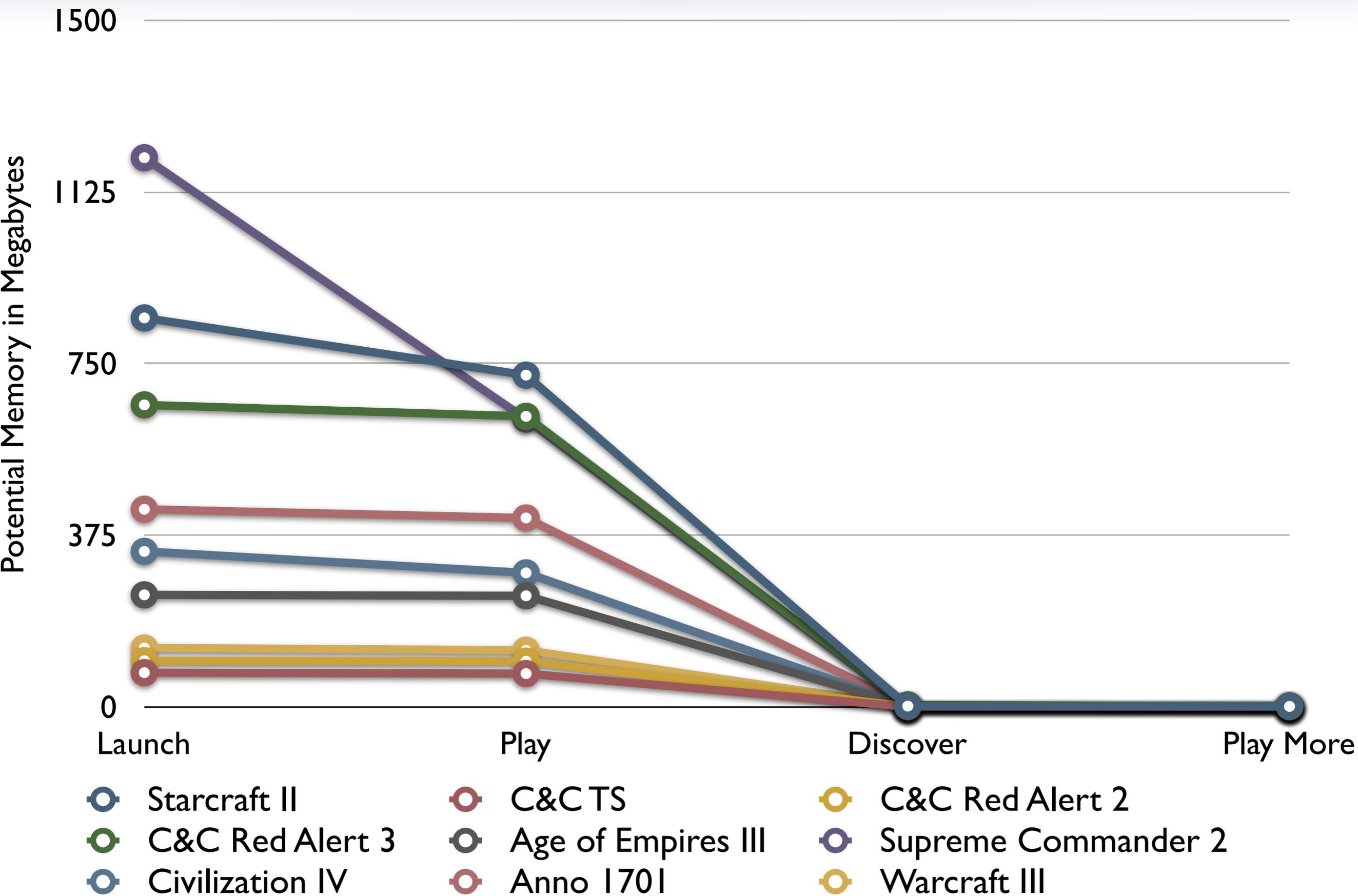


Step 3

Removing more unrelated
memory



Memory reduction algorithm efficiency



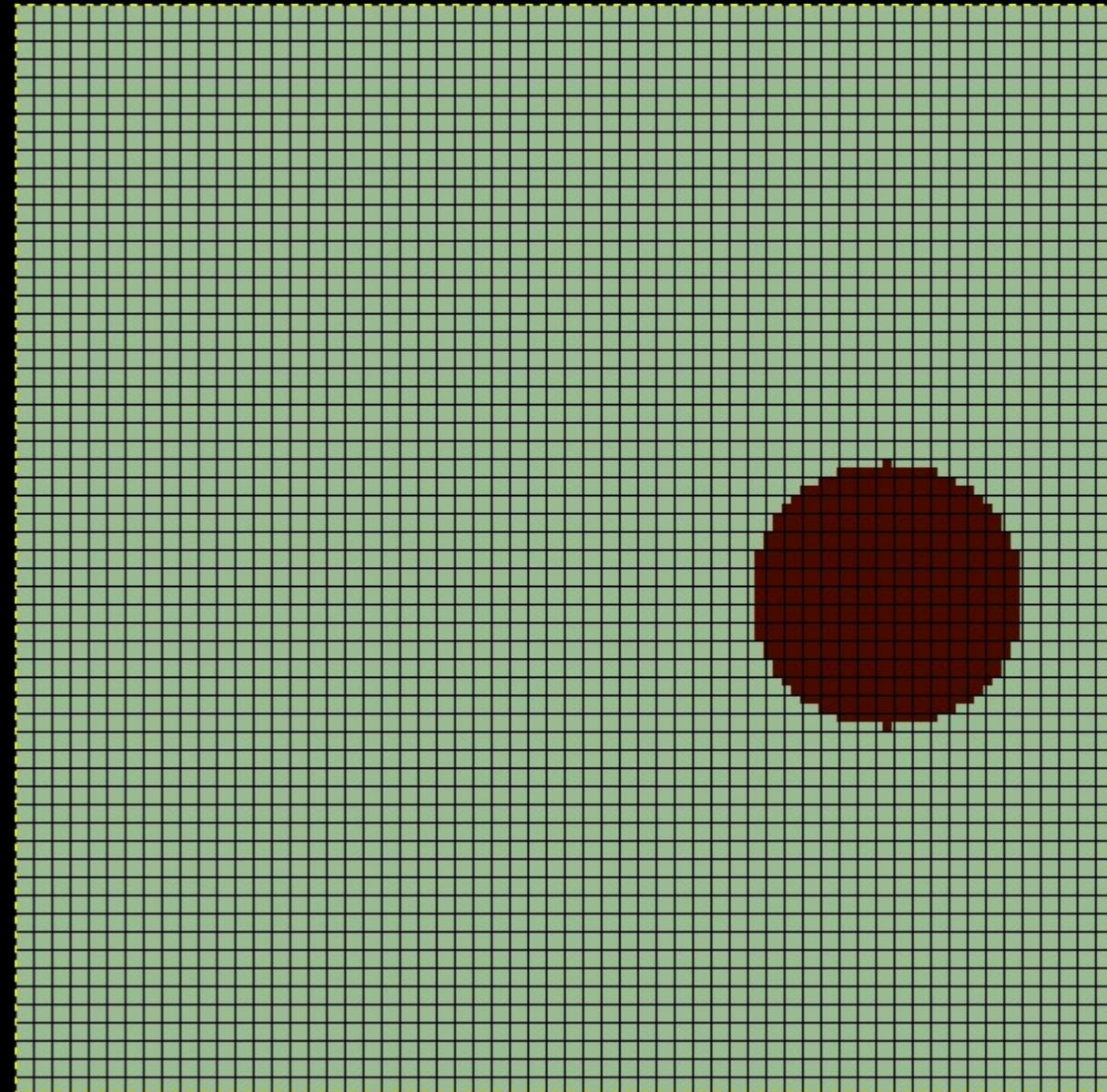
Step 4

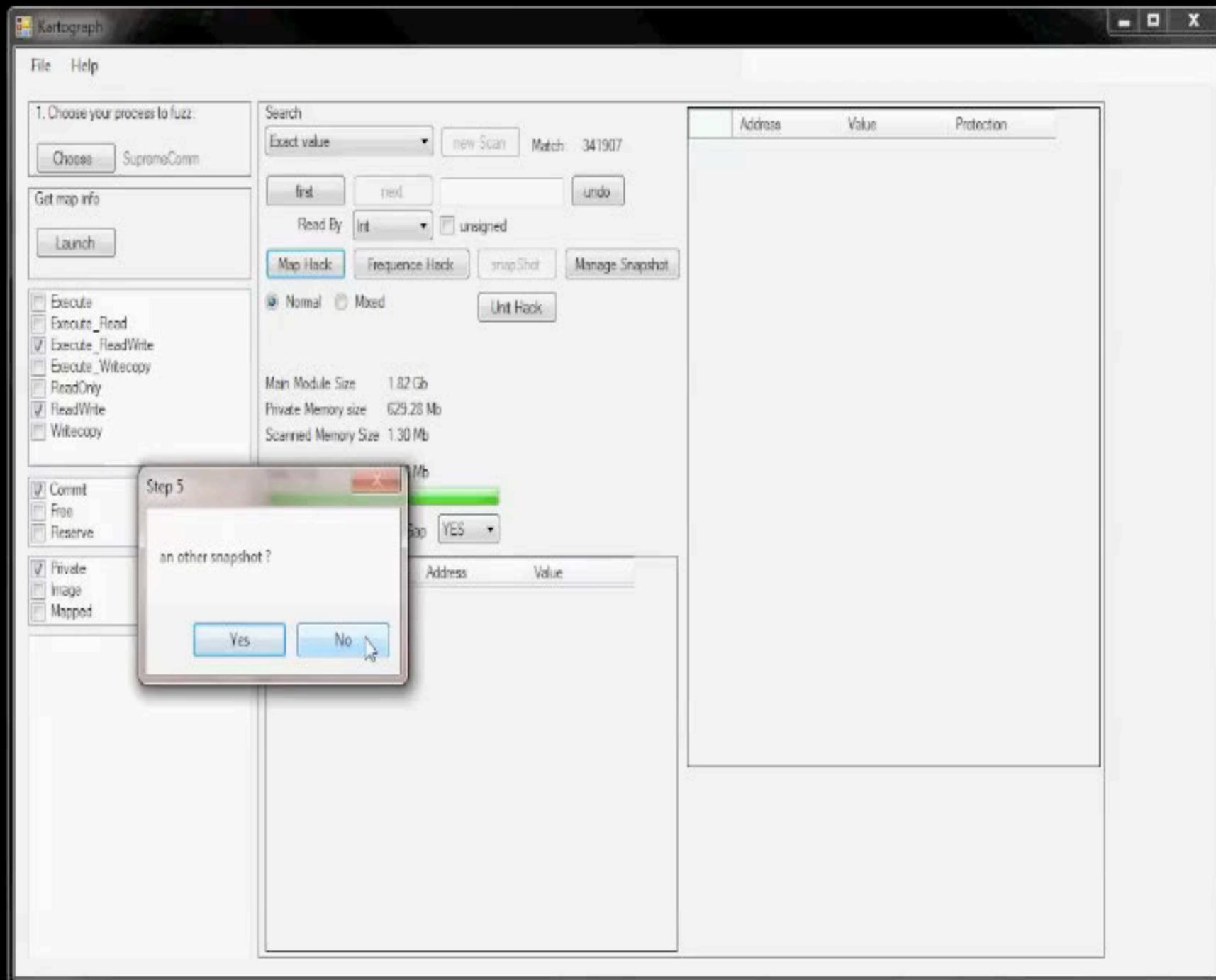
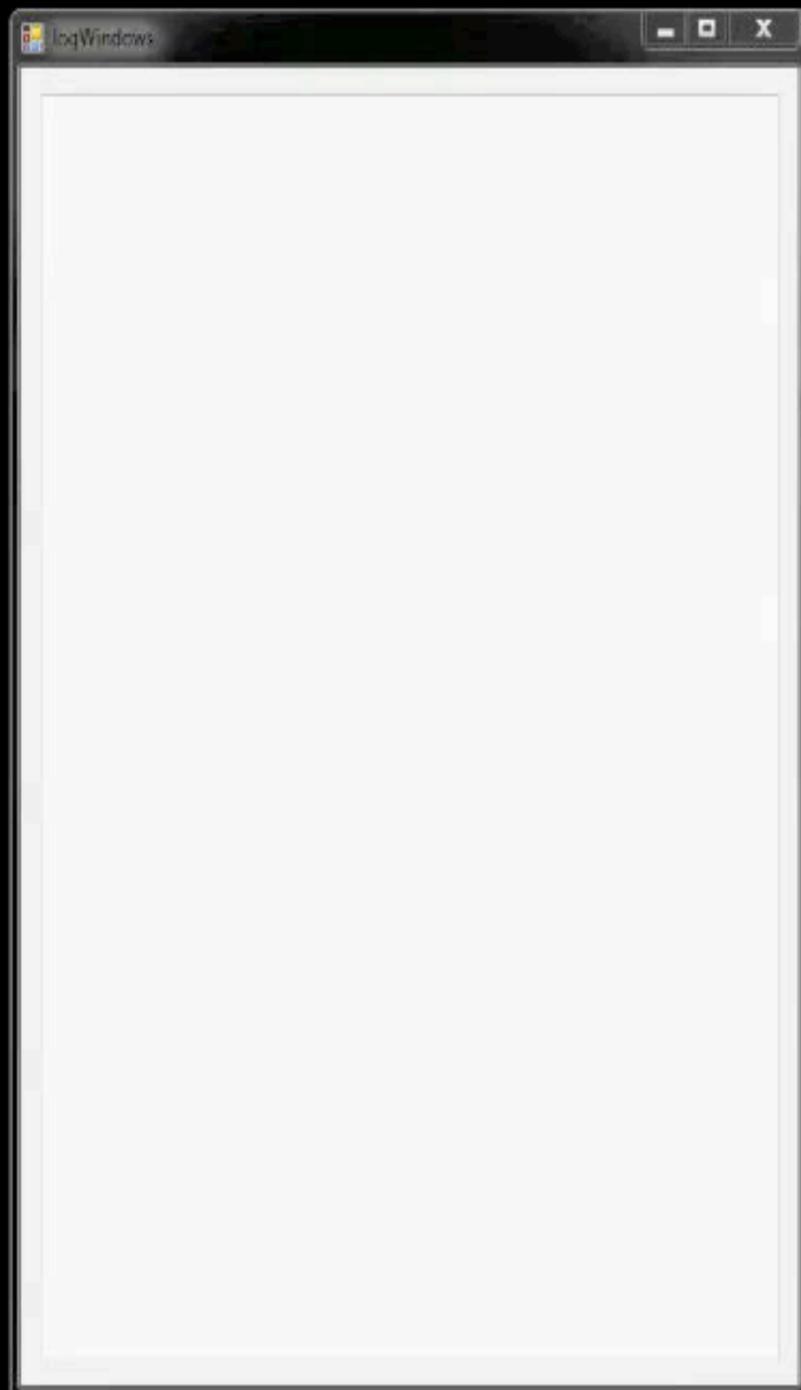
Finding the map in the
remaining memory

Working assumption



Working assumption





Step 5

Isolating the potential map



In game



In memory

Step 6

Understanding the map's
structure



name

target

read

Address	Value	Protection
---------	-------	------------

Step 8

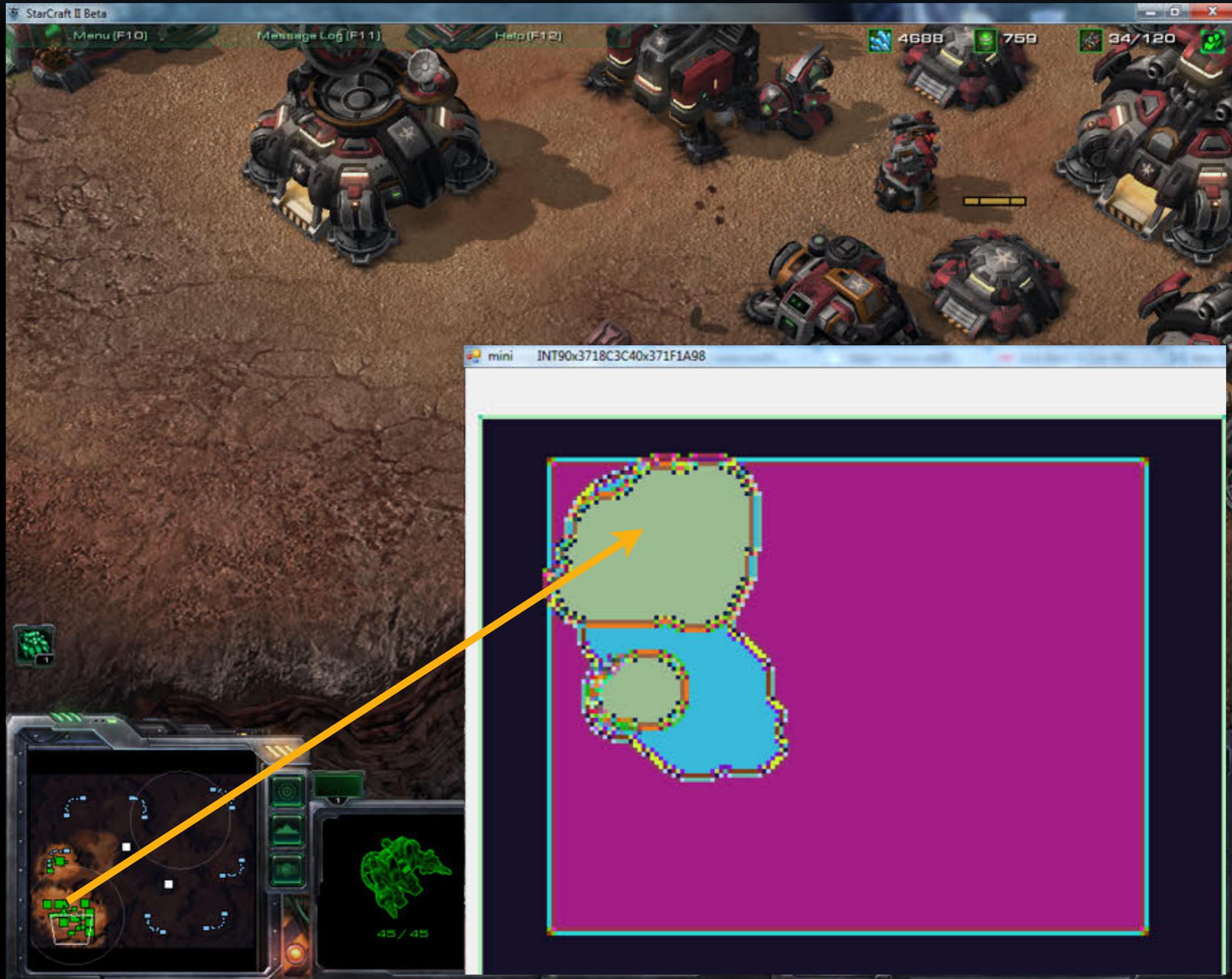
Rewriting game memory
for fun and profit



Starcraft 2 mini map



Starcraft 2 mini map



Unexpected effects



+88

20

Santa Maria

Defense requirements

The passive eavesdropping adversary

- Complete control of his machine
- Can understand the game memory structure
- Can identify and parse any data structure

Attacker objective definition

We say that a passive attacker **defeats** the game if the attacker **can write a program P** that **reveals information** about the opponent **beyond what is revealed by the game's** rules. Otherwise we say that the game is secure against a passive adversary.

Making games secure

- Use two-party (multi-party) cryptography protocol to ensure that the memory contains only the data the user need

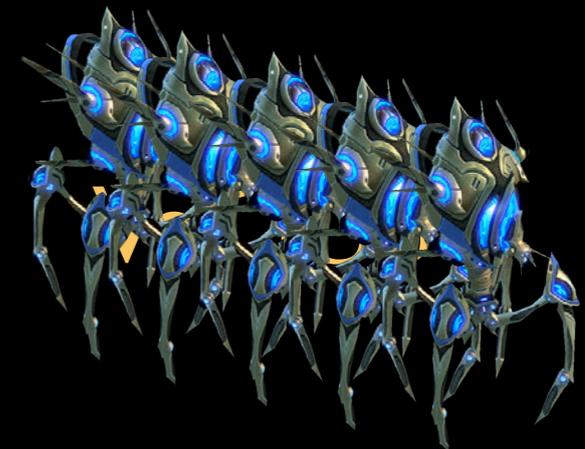
Set intersection protocol



Alice



Bob



Set intersection protocol

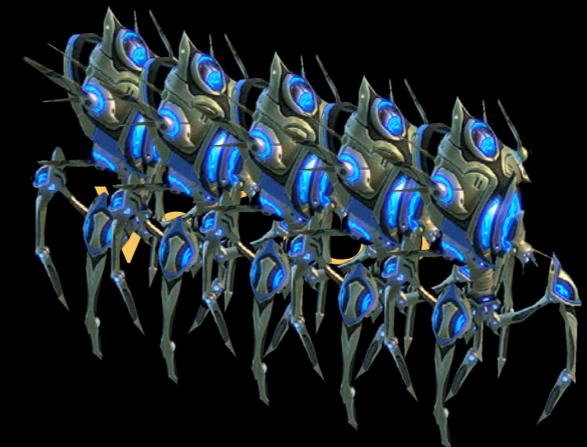


Alice

V_a



Bob



Set intersection protocol



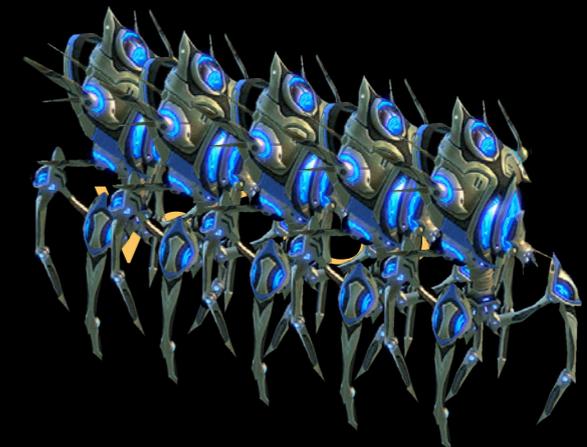
Alice

V_a



Bob

V_a



Set intersection protocol



Alice

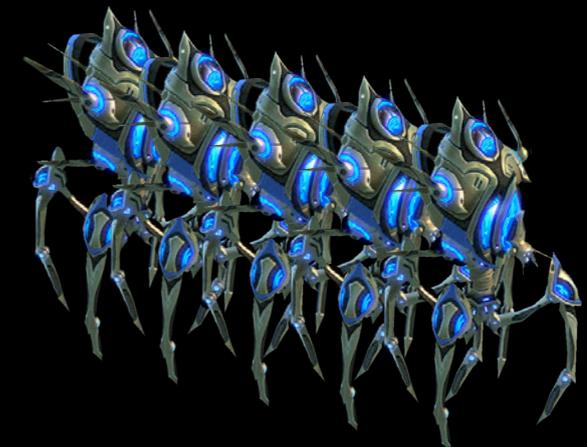
V_a



Bob

V_a

$V_a \cap U_b$



Set intersection protocol



Alice

V_a

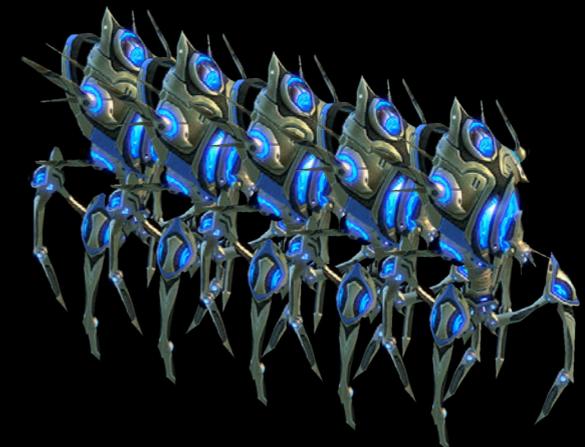
$V_a \cap U_b$



Bob

V_a

$V_a \cap U_b$



Constraints

- Bob learn nothing about V_a
- Alice learn nothing about U_b other than $V_a \cap U_b$

Constraints

- Bob learn nothing about V_a
- Alice learn nothing about U_b other than $V_a \cap U_b$

Computing with these constraints is called the
oblivious intersection set problem

Chosen oblivious intersection protocol

- Due to Jarecki and Liu
- Use an oblivious function evaluation as sub-protocol
- Adapted and optimized for our problem

For one unit



Alice

unit key:

$$o_k(v) := H_1(v)^k \in \mathbb{G}$$



Bob

For one unit



Alice

unit key:

$$o_k(v) := H_1(v)^k \in \mathbb{G}$$



Bob

$$H_1(v)^r$$



For one unit



Alice

unit key:

$$o_k(v) := H_1(v)^k \in \mathbb{G}$$



Bob

$$H_1(v)^r$$



$$H_1(v)^{rk}$$



For one unit



Alice

unit key:

$$o_k(v) := H_1(v)^k \in \mathbb{G}$$



Bob

$$H_1(v)^r$$



$$H_1(v)^{rk}$$

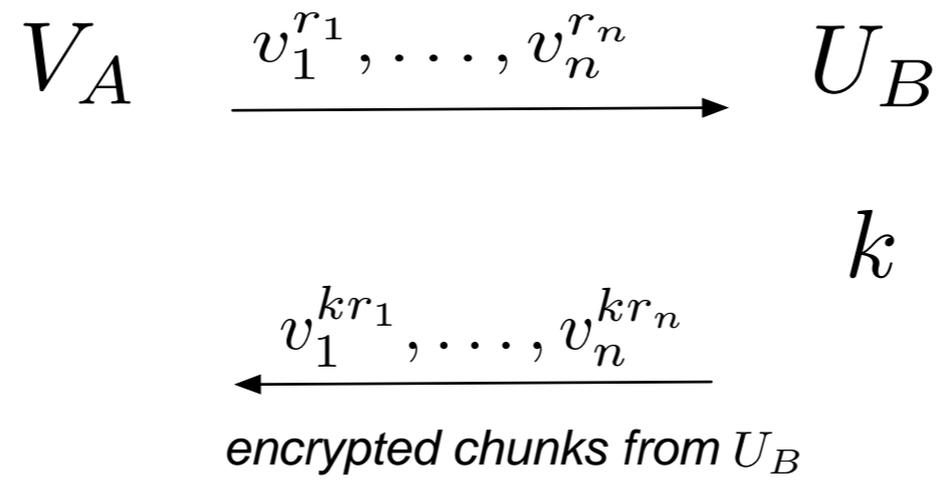


$$H_1(v)^k = H_1(v)^{rkr^{-1}}$$

Multi-units



Alice



Bob

Chaff

- The basic protocol leaks information
 - The number of Alice visible cell
 - The number of bob unit (nb encrypted chunk)
- Both are resolved by adding a chaff
 - Bob and Alice add random values that “pad” the data

Challenge

Design a protocol that is fast enough so the added game latency is imperceptible to users.

SINGLE
PLAYER

MULTI
PLAYER

STARCRRAFT
WINGS OF LIBERTY



Light
1075

CREATE PARTY

REPLAYS



RECENT

MULTIPLAYER

VERSUS A.I.

CHALLENGE

NAME

DATE

<input checked="" type="checkbox"/> Dig Site (2)	Nov 12, 2010 10:14:58 PM
<input checked="" type="checkbox"/> Ulaan Deeps	Nov 12, 2010 9:59:18 PM
<input checked="" type="checkbox"/> Colony 426 (3)	Nov 12, 2010 9:31:51 PM
<input checked="" type="checkbox"/> The Bio Lab (2)	Nov 12, 2010 8:55:01 PM
<input checked="" type="checkbox"/> Monsoon	Nov 12, 2010 8:16:16 PM
<input checked="" type="checkbox"/> Arakan Citadel (3)	Nov 12, 2010 7:23:09 PM
<input checked="" type="checkbox"/> Typhon	Nov 12, 2010 6:43:09 PM
<input checked="" type="checkbox"/> Kulas Ravine	Nov 12, 2010 6:09:34 PM
<input checked="" type="checkbox"/> Frontier (3)	Nov 8, 2010 10:54:37 PM
<input checked="" type="checkbox"/> Ulaan Deeps (7)	Nov 8, 2010 9:51:55 PM

DETAILS

Dig Site

DURATION: 19:41
VERSION: 1.1.3.16939



bitwise - Protoss
Colaldor - Terran
Light - Zerg
nomadicpuma - Protoss
Anson - Terran
Sulla - Protoss

Establishing a **baseline**

Methodology

- 1000 Starcraft 2 replays from pro-gamer
- Game duration
- Number of units by players
- Number of visible cells
- Number of actions by seconds
- Map playable size:
 - min **15180** cells
 - max **24640** cells



Analysis difficulty

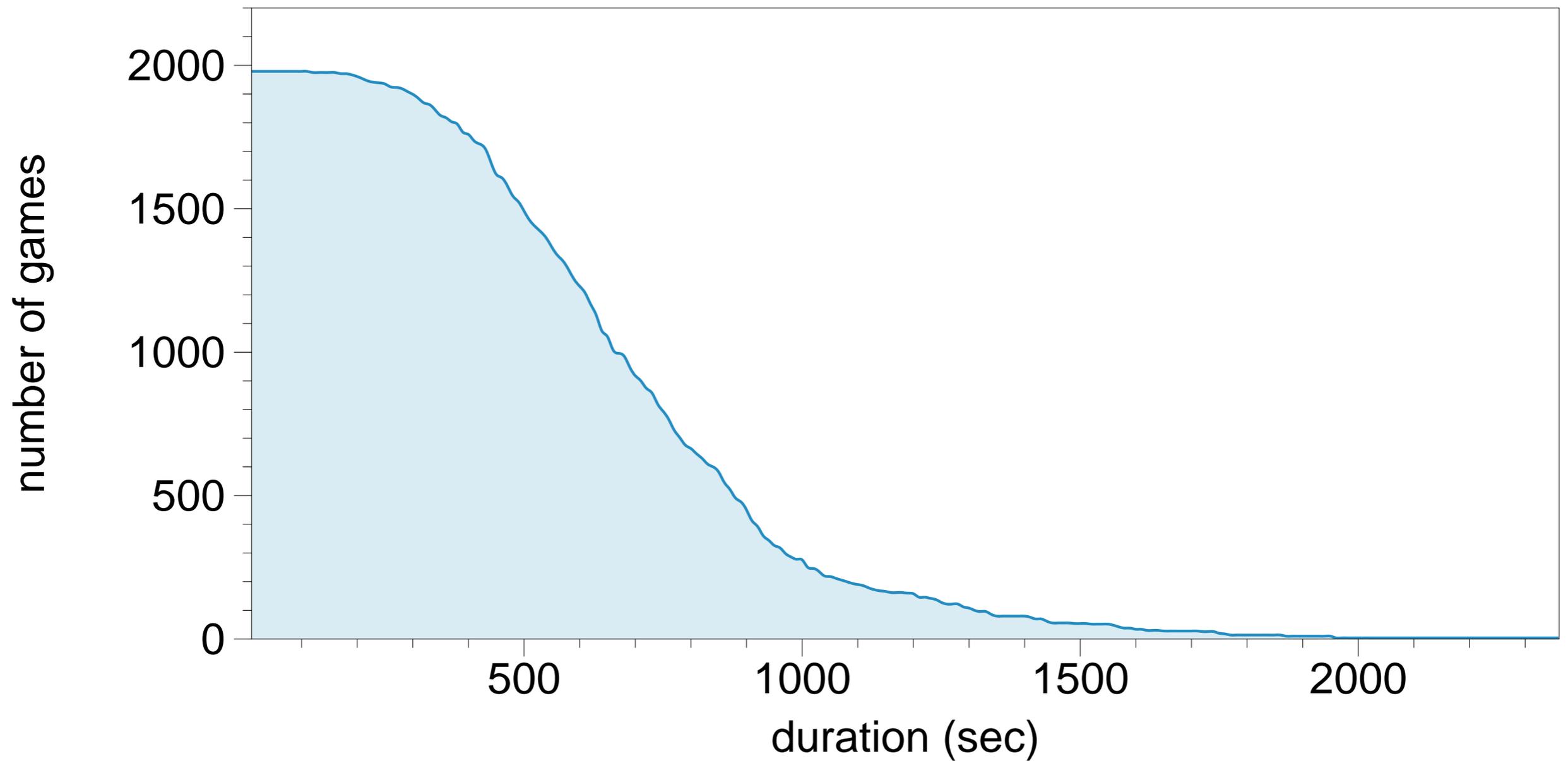
1. Replays use a proprietary file format (MQP)

- Wrote a custom parser

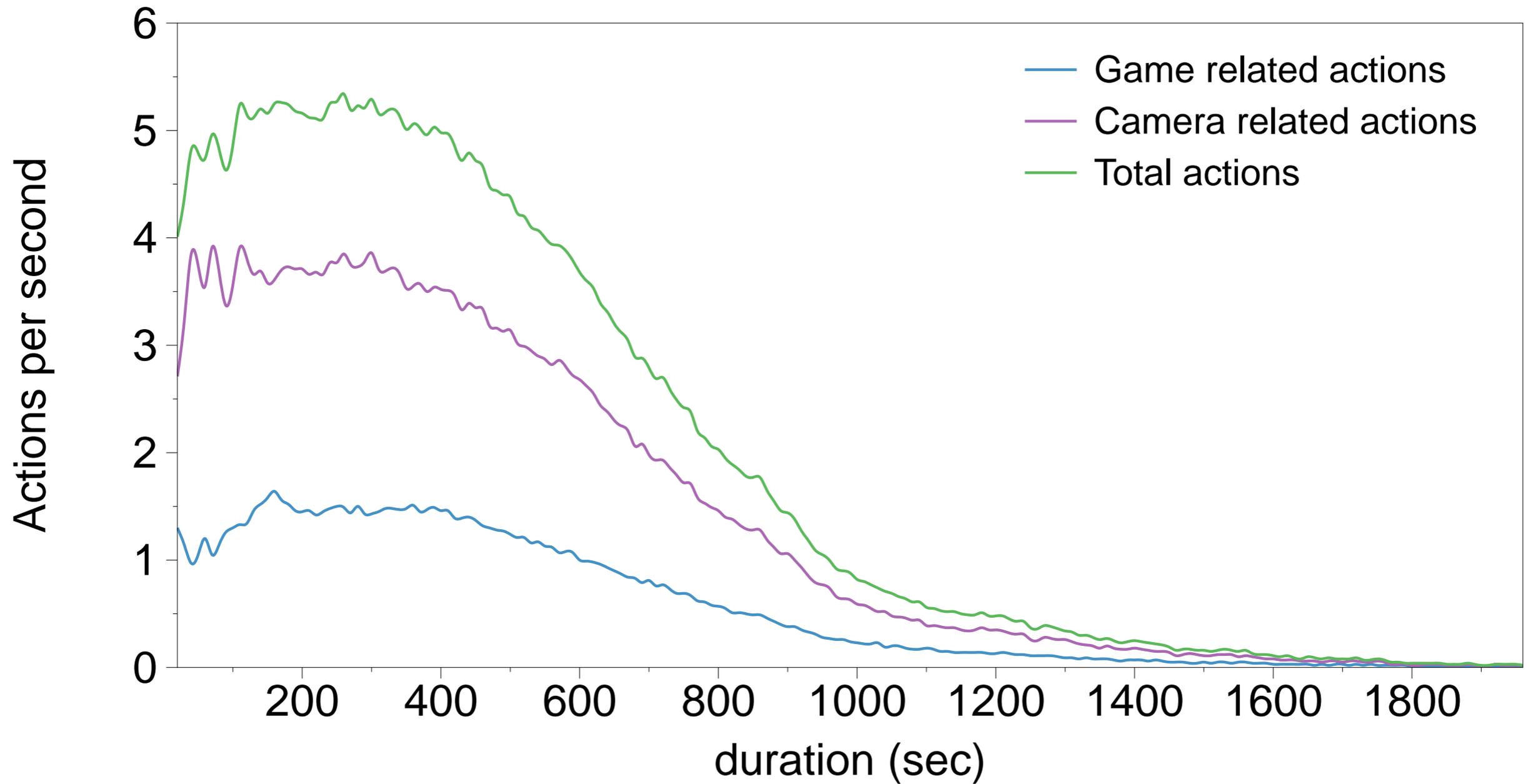
2. Replay only record players actions

- Wrote a minimal game engine
- return an upper-approximation

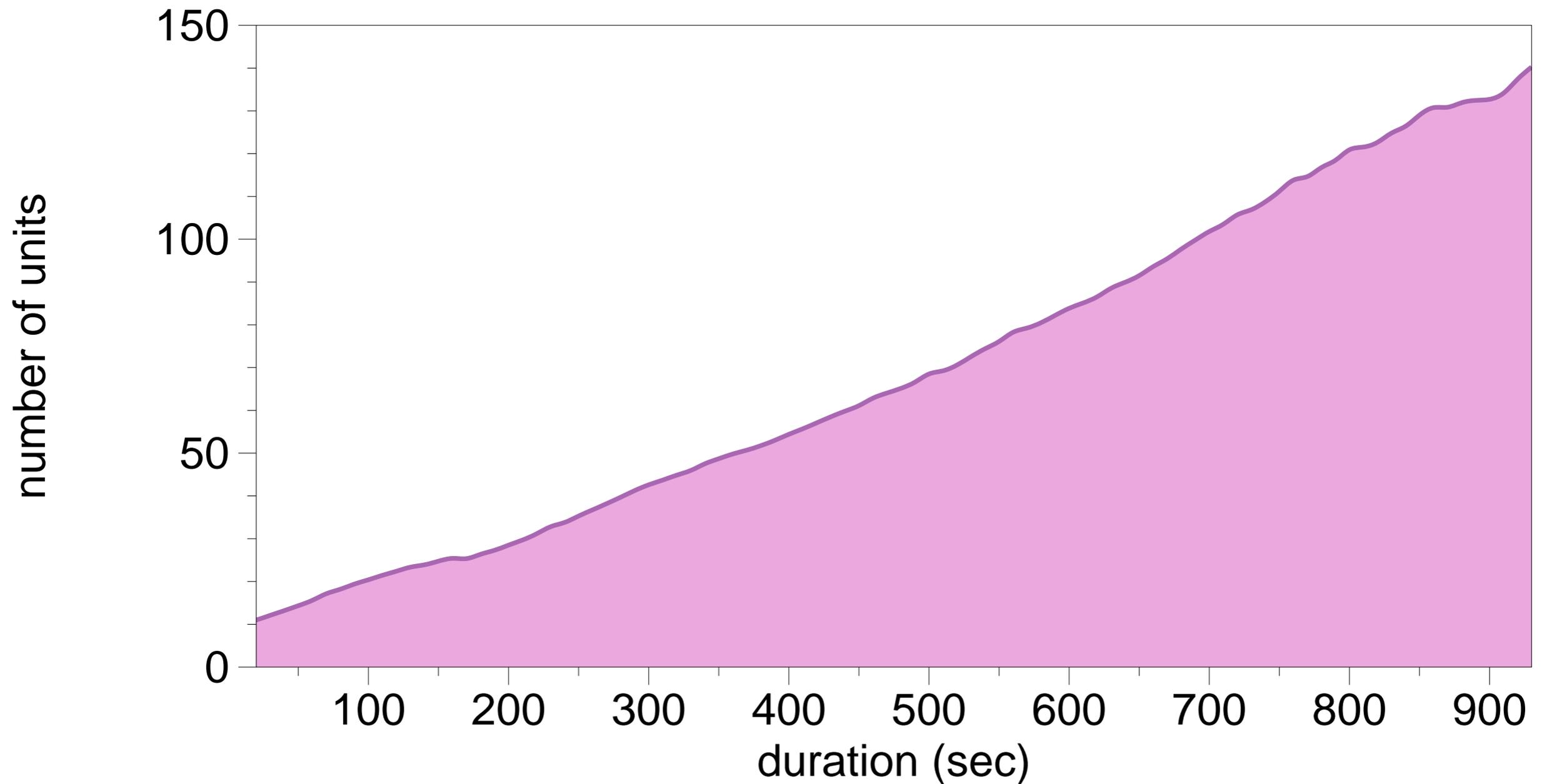
Game duration



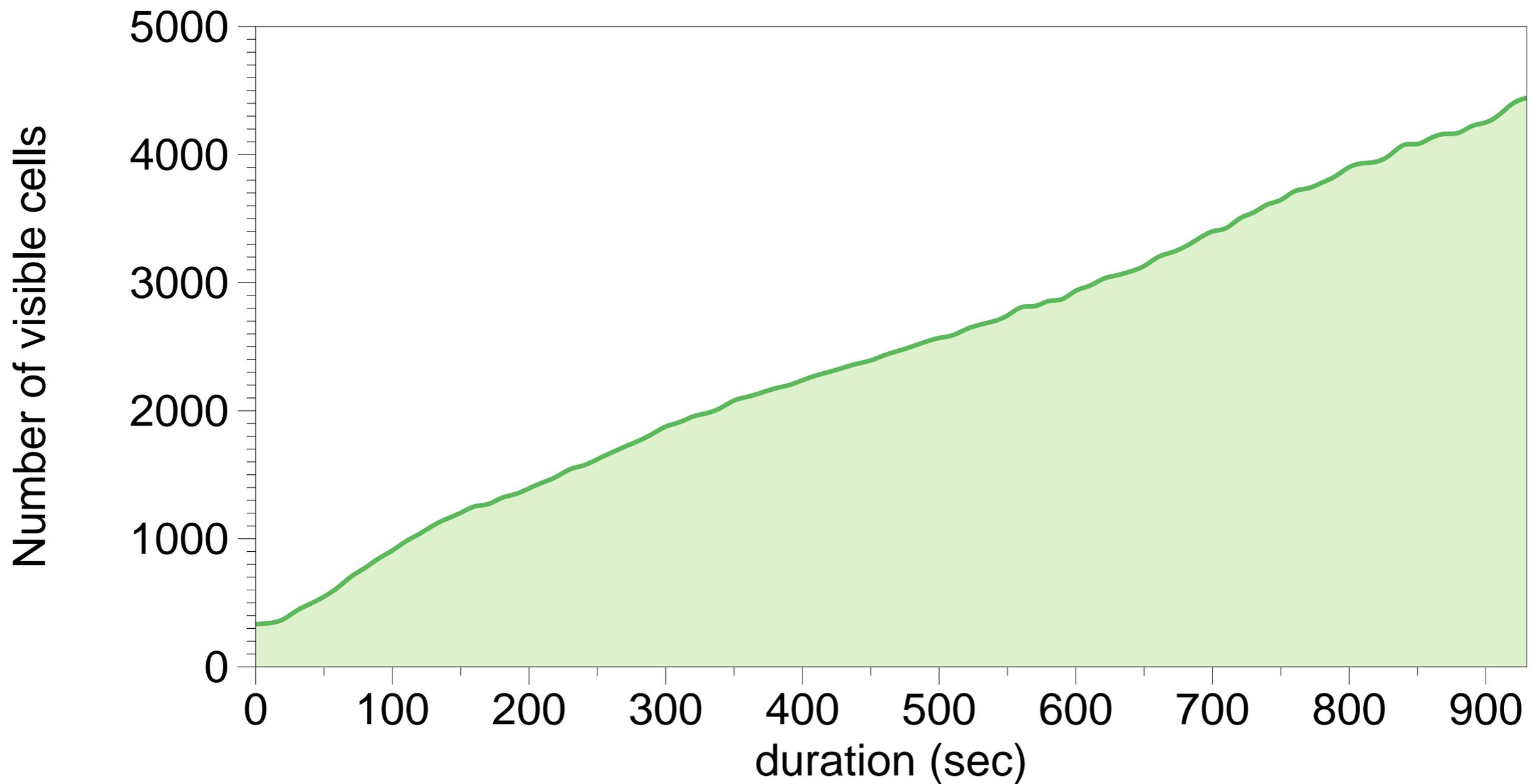
Actions per second



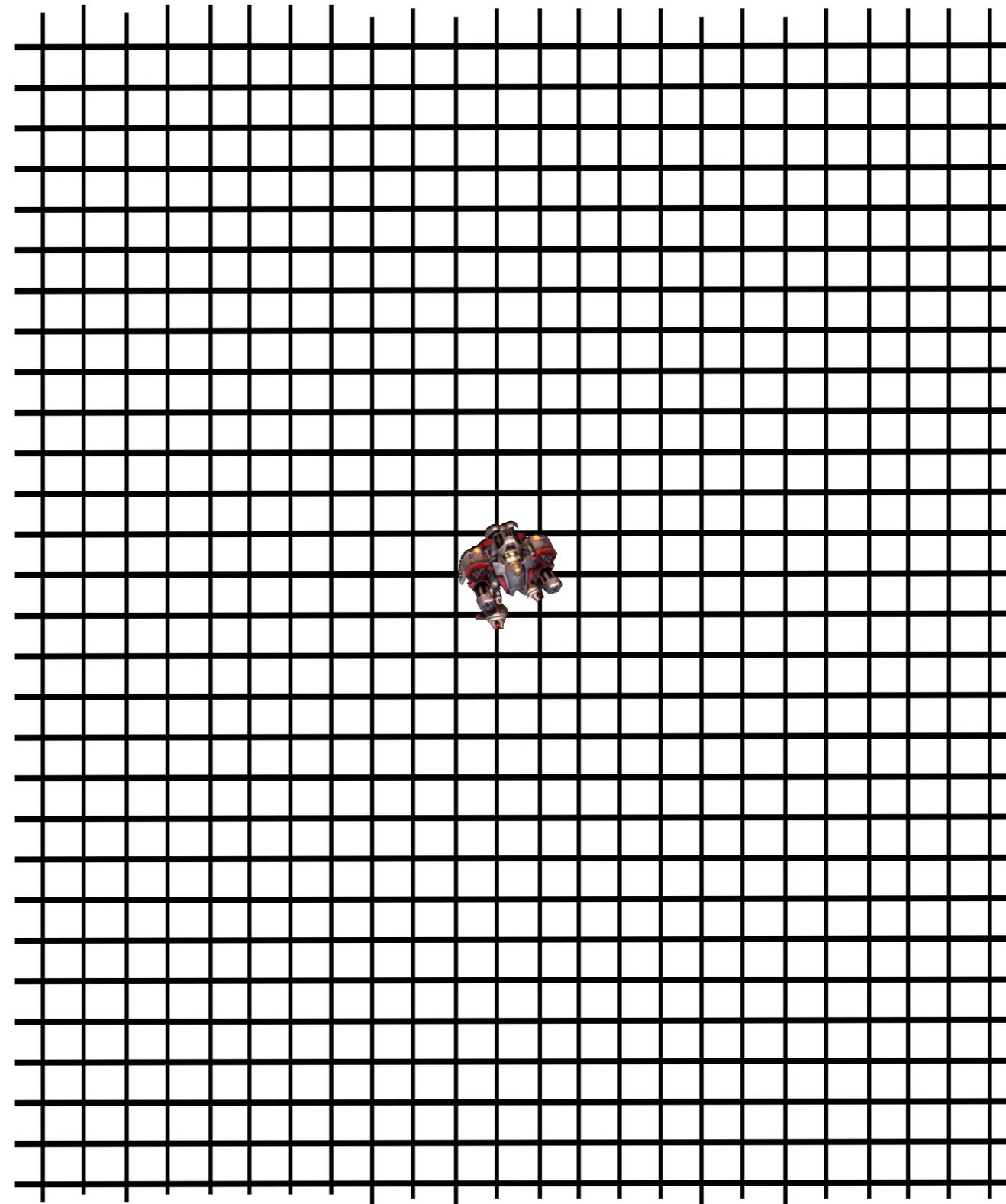
Units by duration



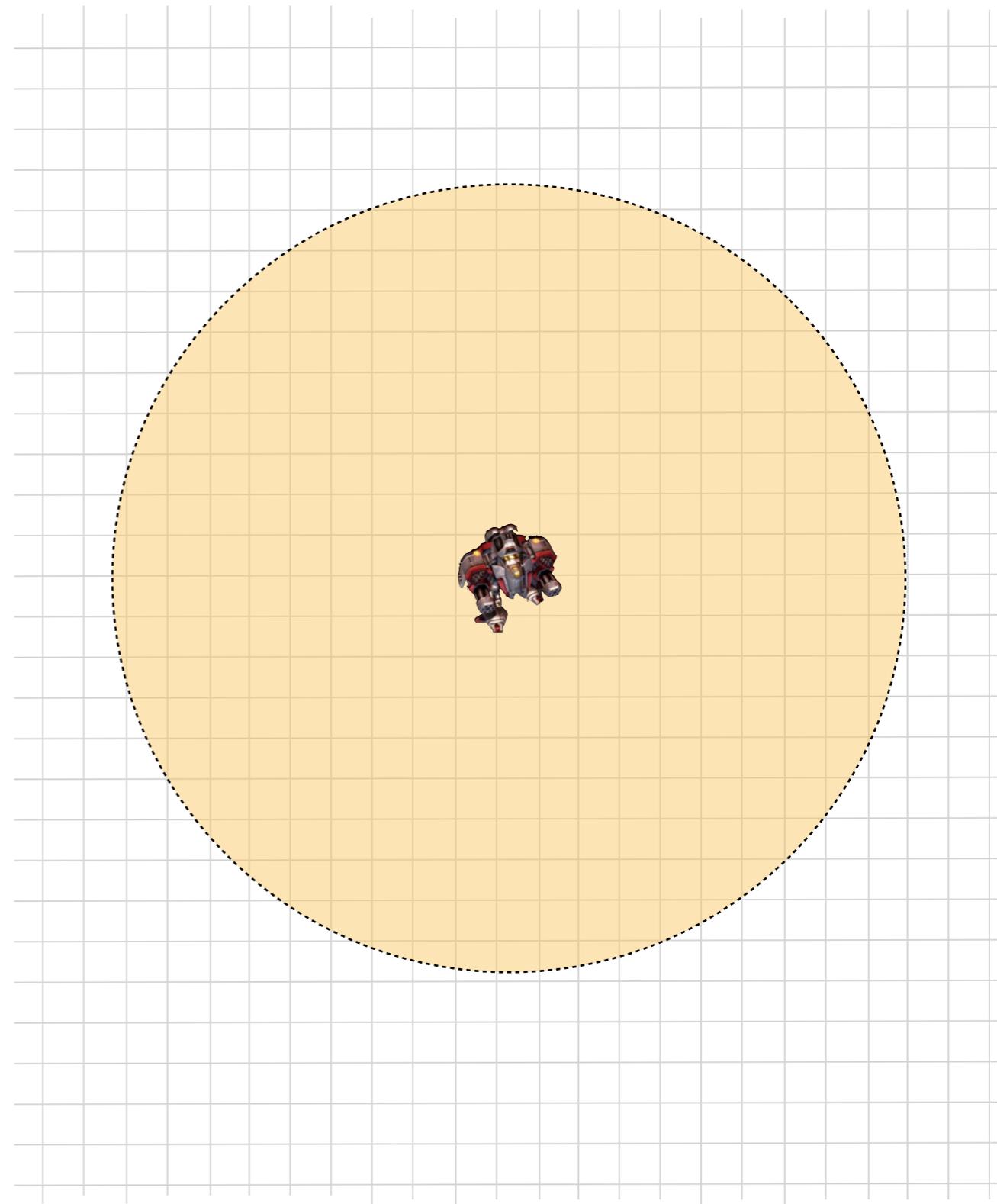
Map cell visible by duration



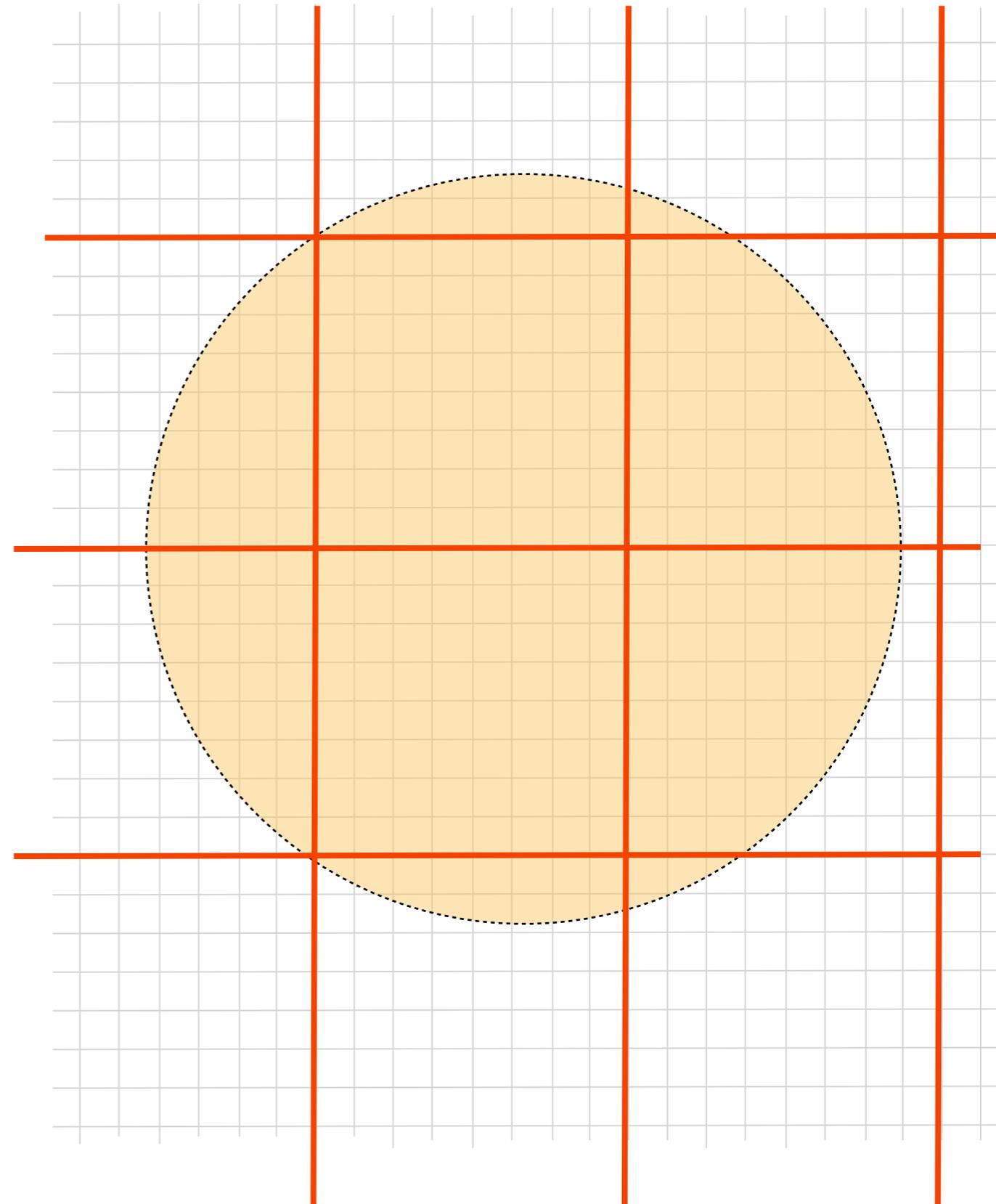
- Hypergrid: 4 grid instead of 1
- 1x1 cells
- 2x2 cells
- 3x3 cells
- 4x4 cells
- Least visible cells
- 4 times more units



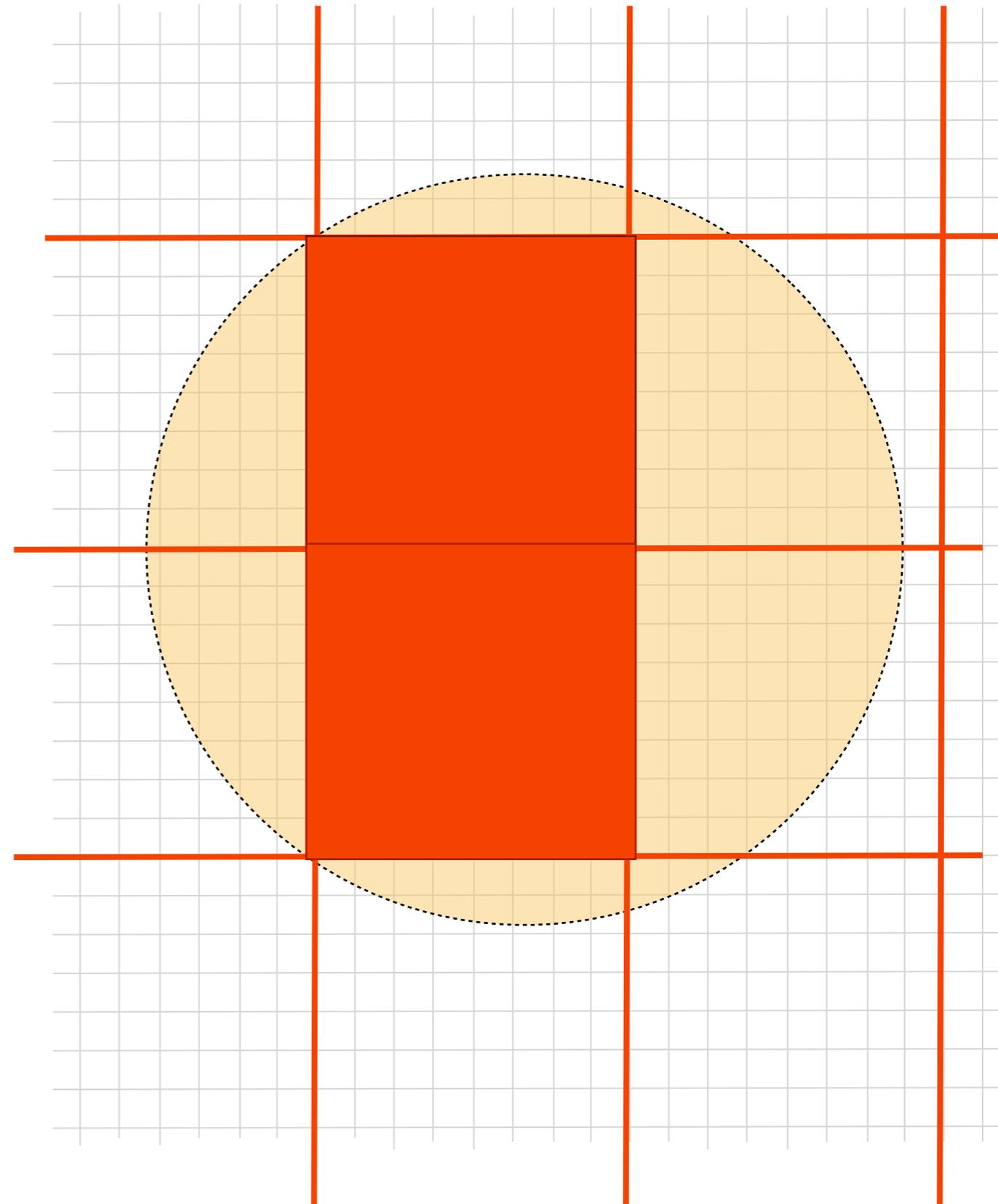
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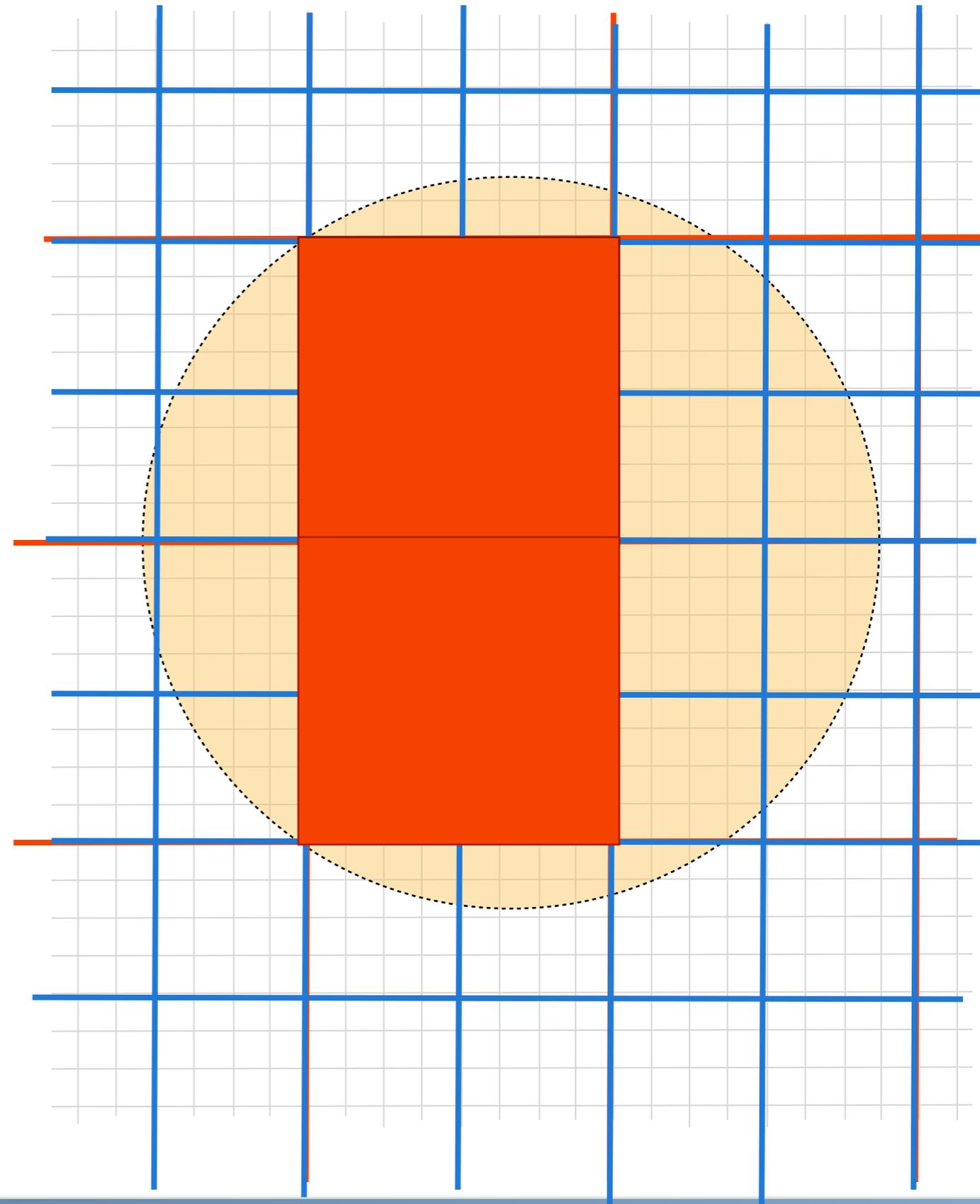
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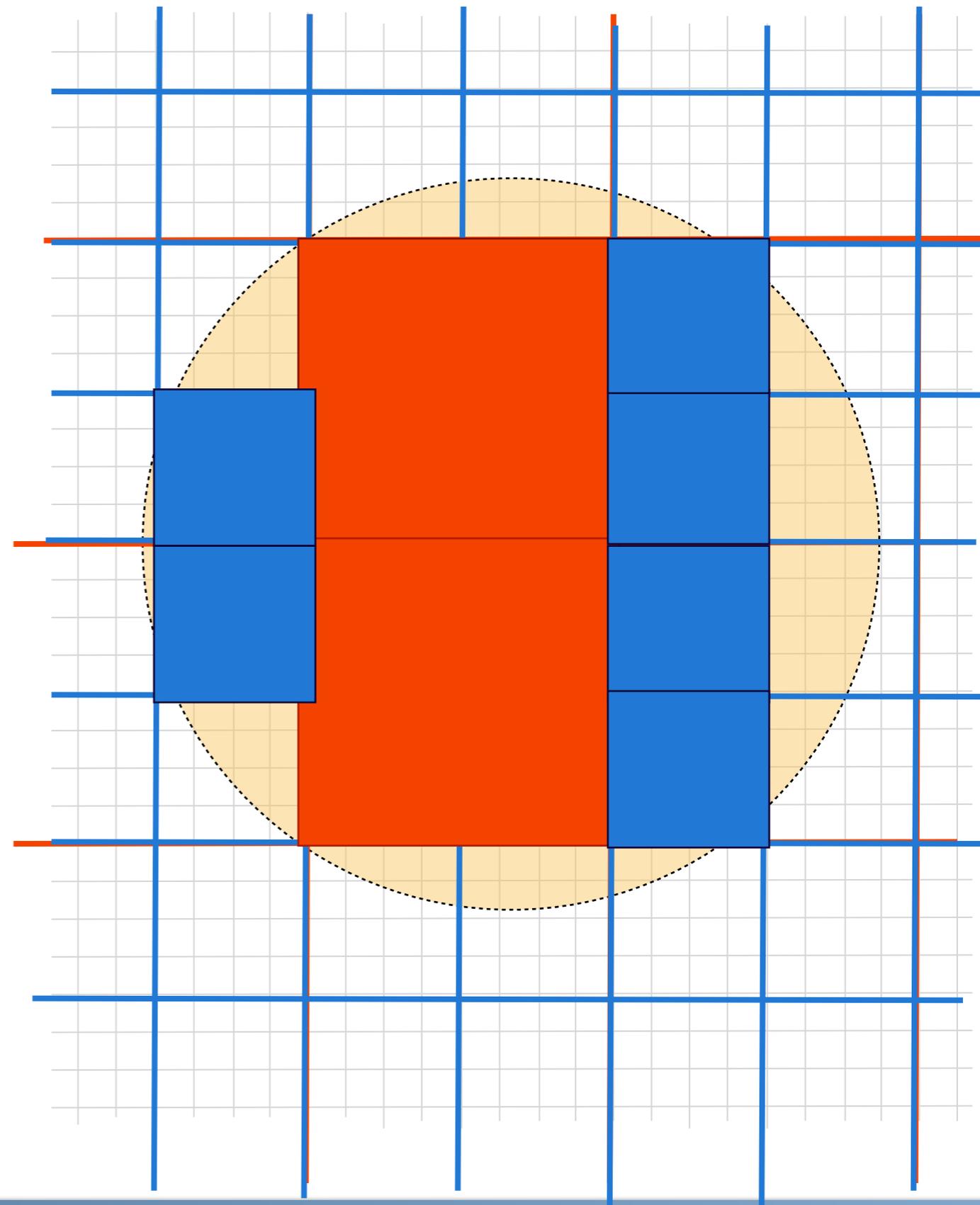
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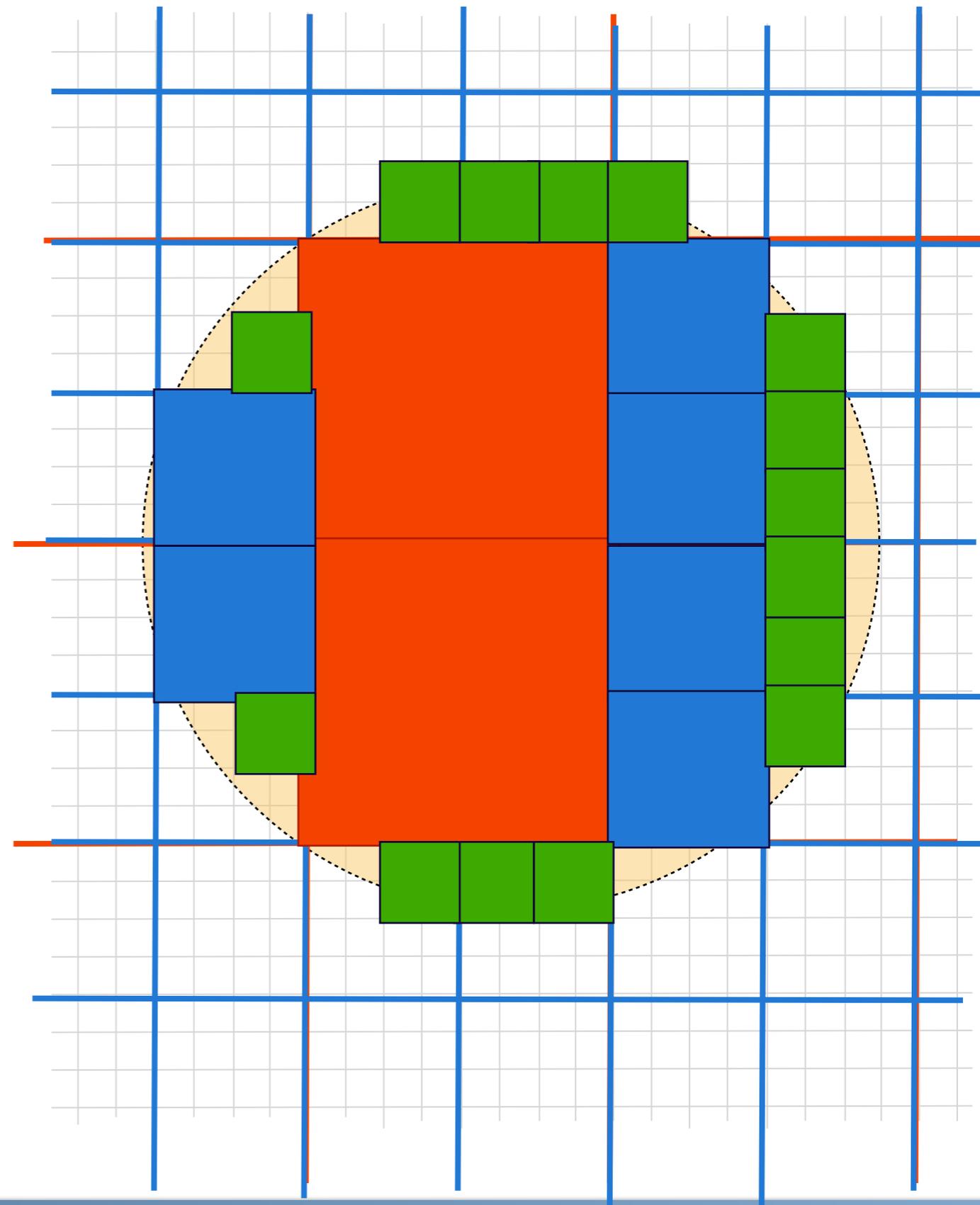
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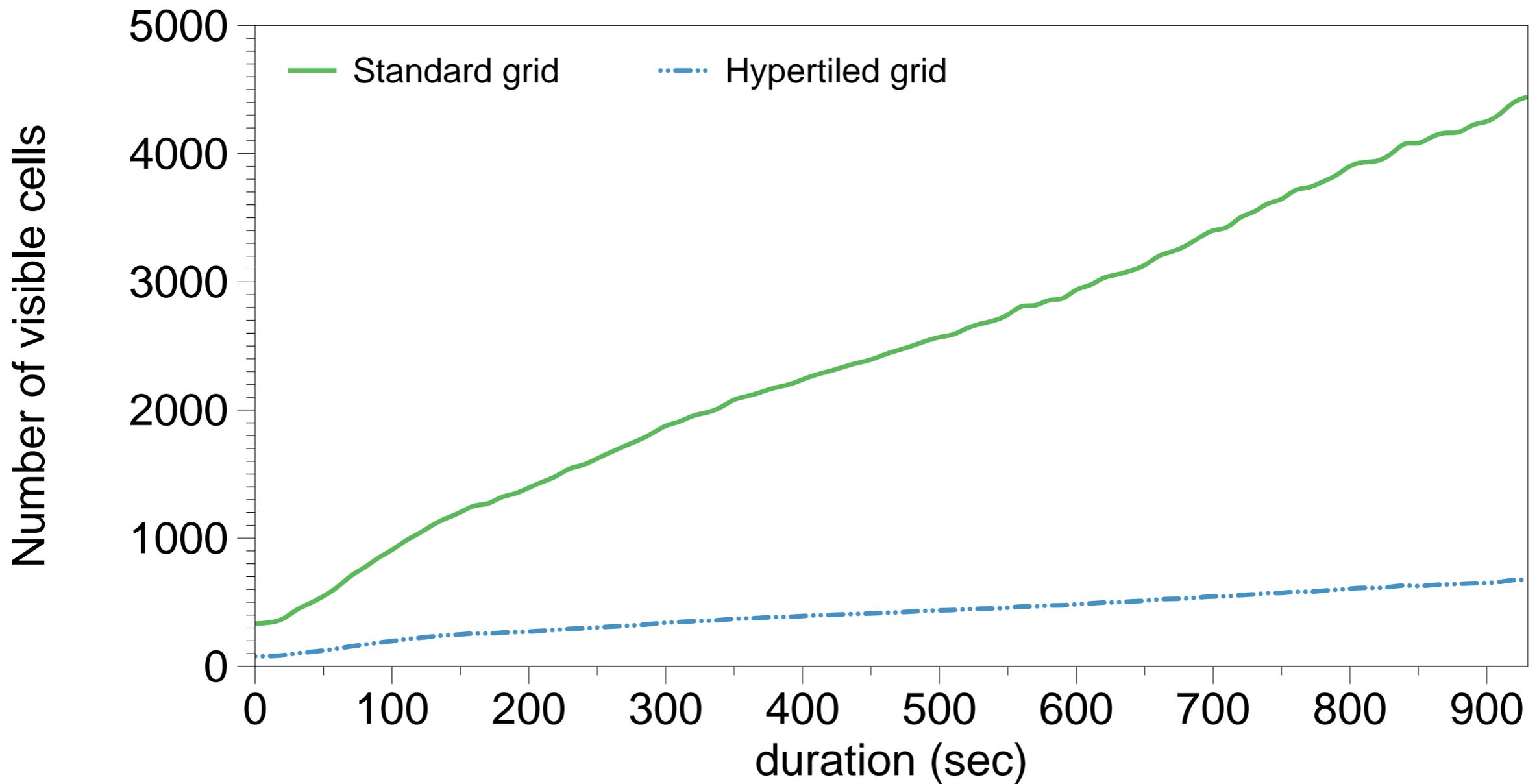
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- Hypergrid: 4 grid instead of 1
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- 2x2 cells
- 3x3 cells
- 4x4 cells
- Least visible cells
- 4 times more units



Impact of the hypertiled grid



Open-Conflict Benchmark

$v \downarrow u \rightarrow$	100	200	300	400	500
100	5ms	6ms	8ms	9ms	11ms
200	8ms	9ms	11ms	12ms	14ms
300	11ms	13ms	14ms	16ms	17ms
400	14ms	16ms	17ms	19ms	20ms
500	17ms	19ms	20ms	22ms	24ms

Conclusion

- Developed a generic method to perform memory based attack
- Established a defense performance baseline based on real world data
- Designed and implemented an oblivious set intersection protocol that prevents passive attacks
- Future work: defending on active attacks

Thank you !



Paper and video available from <http://ly.tl/p19>

Twitter: [@elie](https://twitter.com/elie)

Finding units information

When things become harder

- Unit lists are very small
- Visualization won't work this time to find it :(
- Solely based on memory shape analysis algorithms

Stack detection heuristics

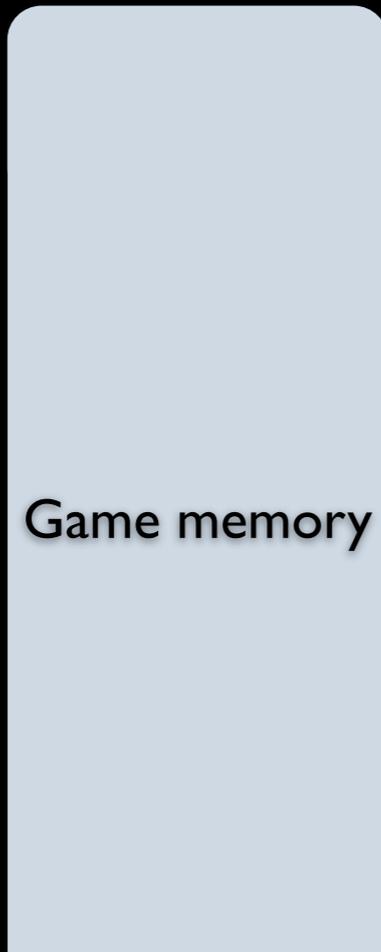
- Only one new integer by unit
- Each integer is a valid pointer

Unit hack Step



Game memory

Unit hack Step



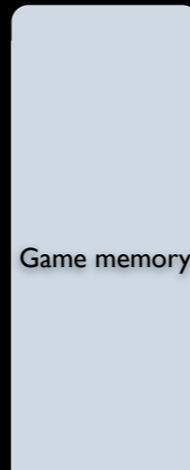
Game memory

Unit hack Step



Game memory

Unit hack Step



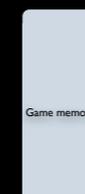
Game memory

Unit hack Step

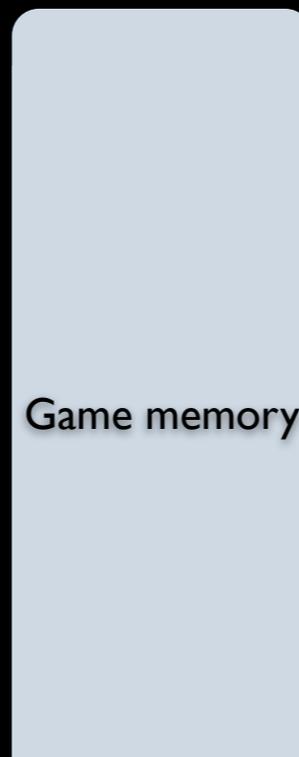


Game memory

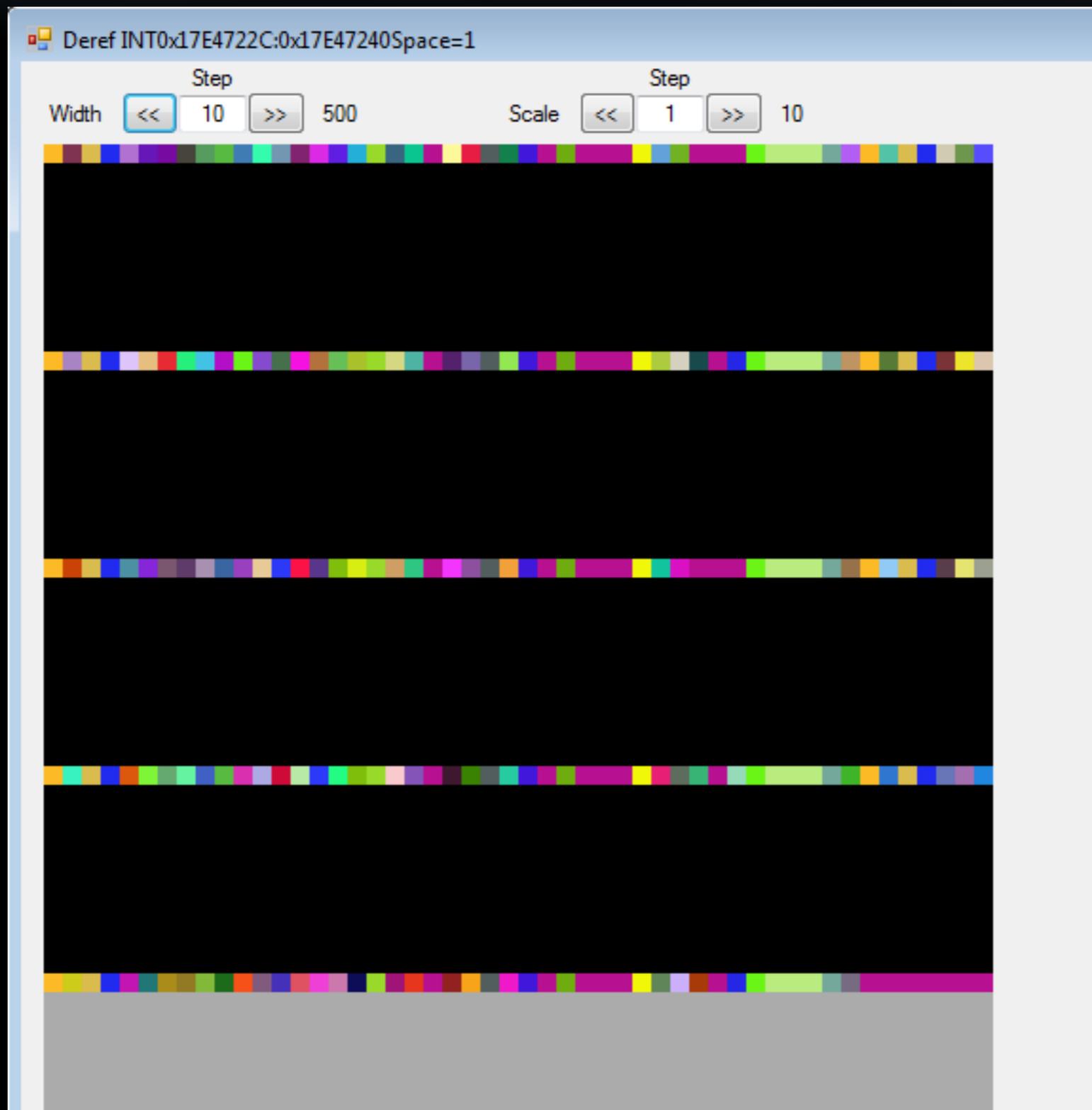
Unit hack Step



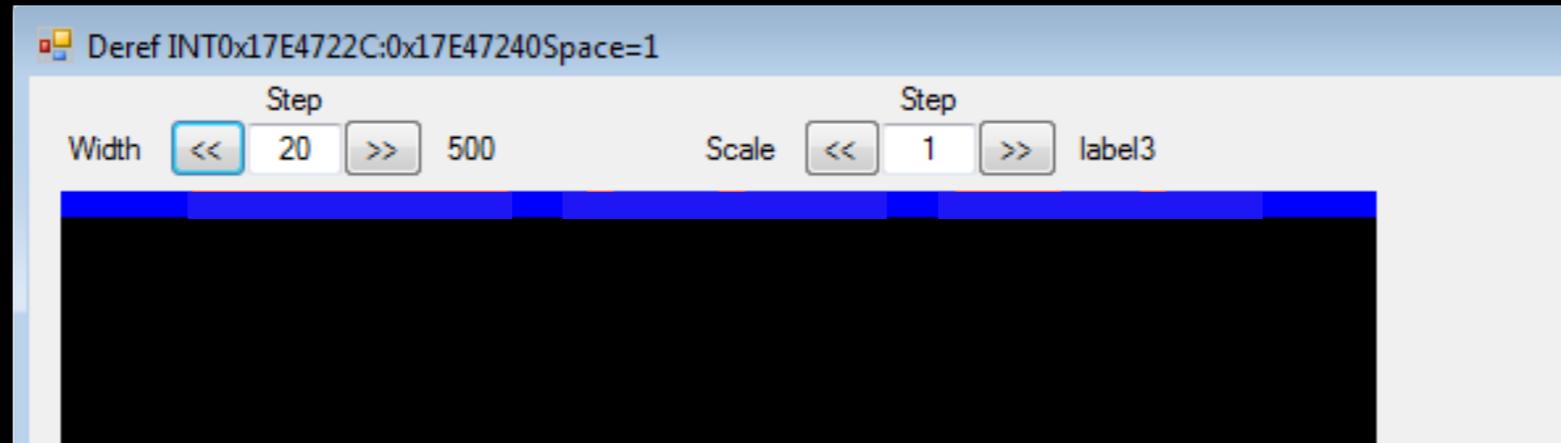
Unit hack Step



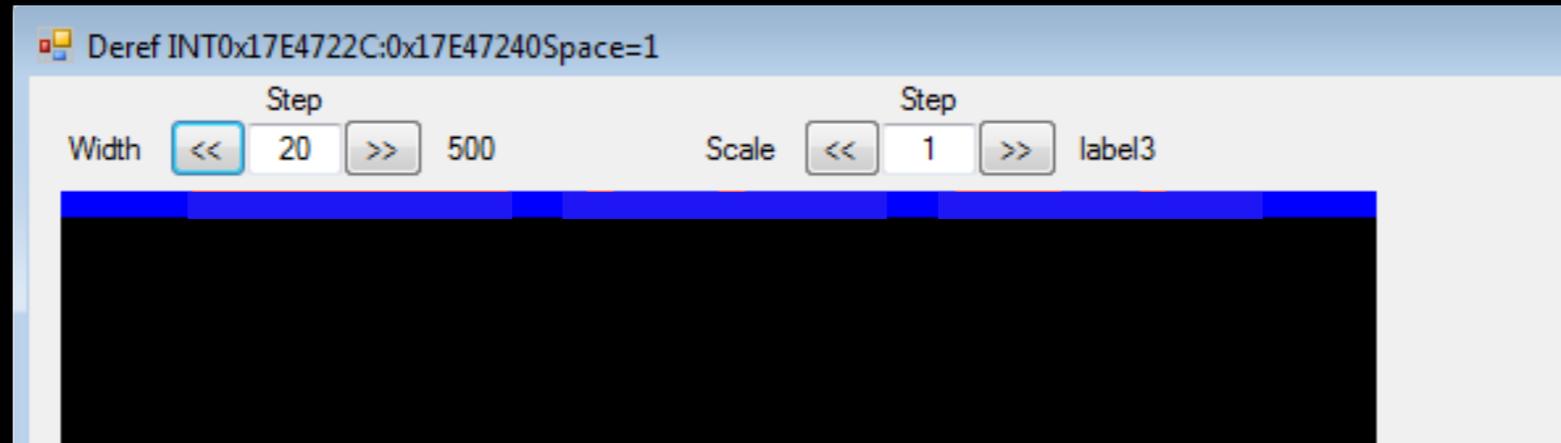
Unit Hack shape



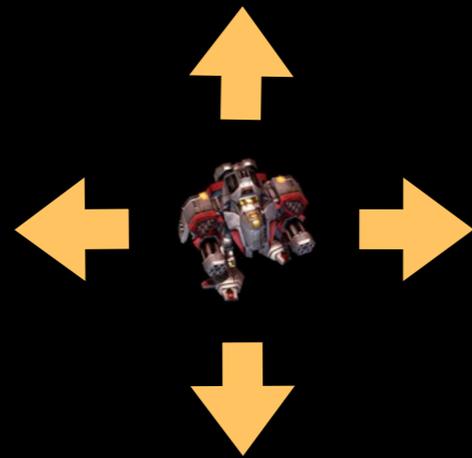
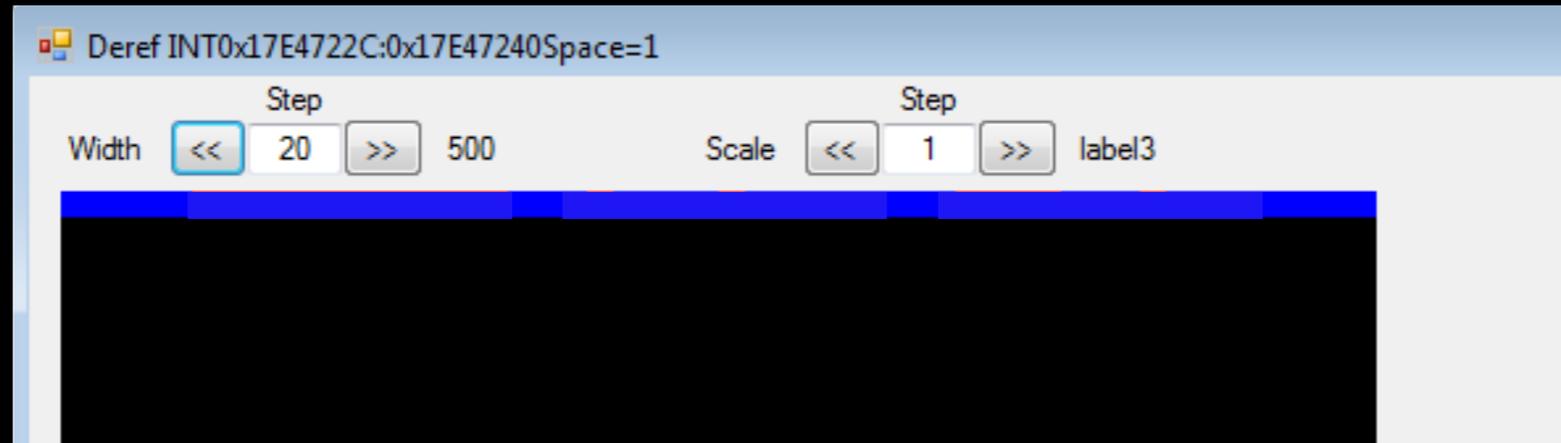
Understanding unit structure



Understanding unit structure

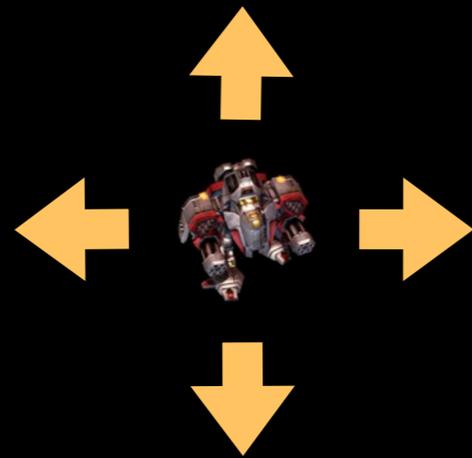
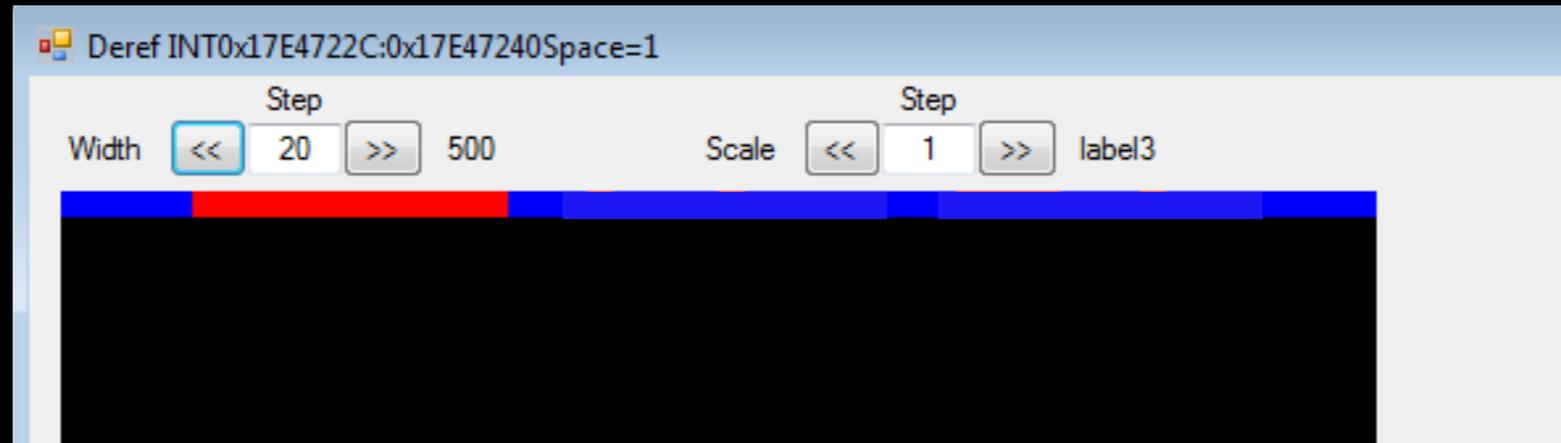


Understanding unit structure



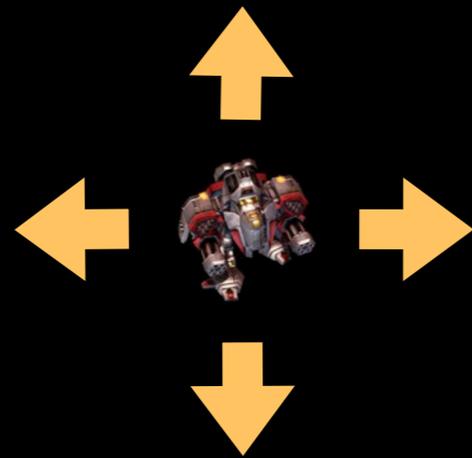
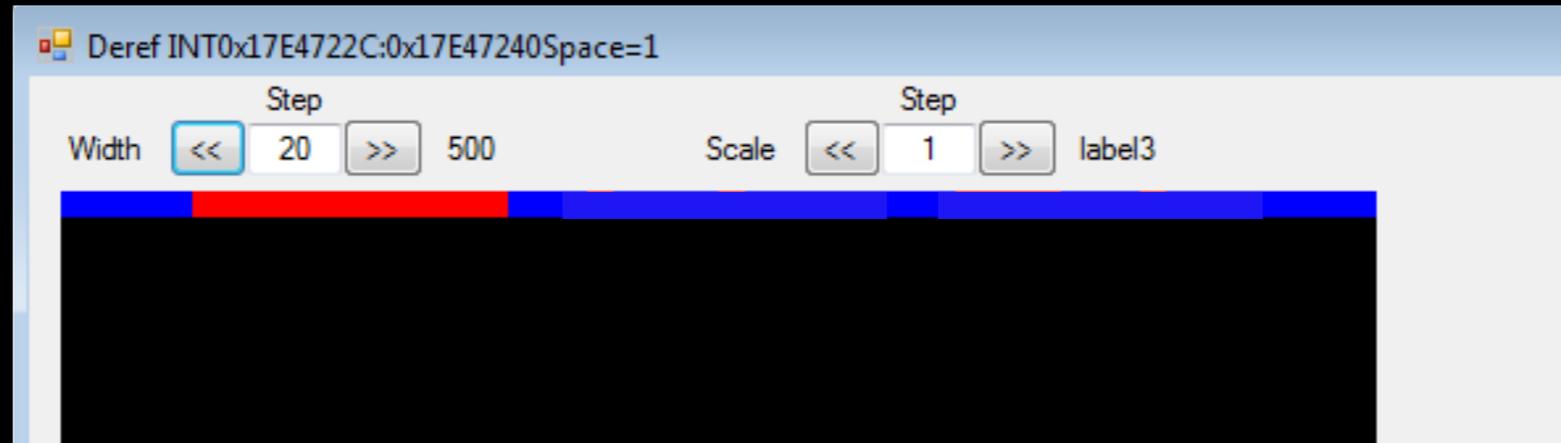
make it move

Understanding unit structure



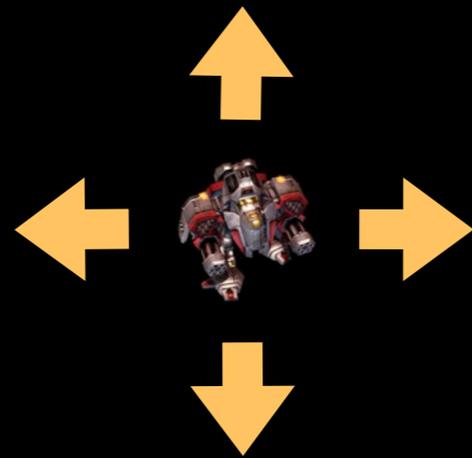
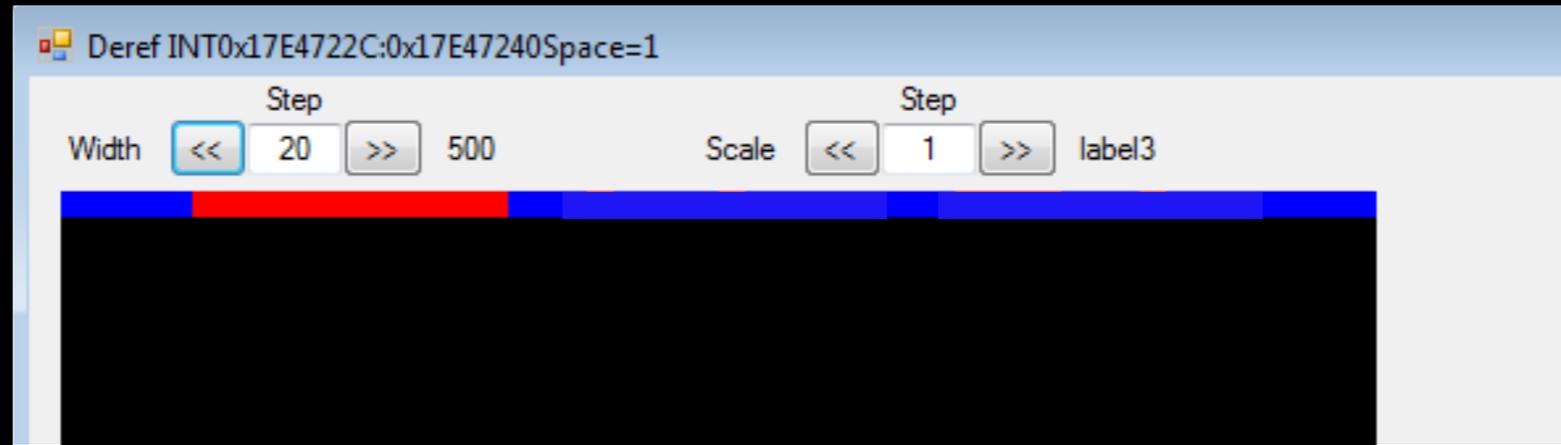
make it move

Understanding unit structure



make it move

Understanding unit structure



make it move



make it bleed

Kartograph performance

Game	Unit 1	Unit 2	Unit 3	Unit 4	Unit 5
Supreme Commander 2	176454	13546	428	55	12
Age of empire 3	3443	177	48	29	10

V: Imperial Age

Menu



Imperial Nassauer
· Hand infantry



 6
 10 / 110
 2293
 1359
 925

 4
Imperial Espada


Commands





Kartograph performances

Game	Launch	Play	Discover	Play more
Starcraft 2	850	725	2	1.3
C&C Tiberium Sun	75M	73M	400K	400K
C&C Red Alert 2	101M	100M	935K	915K
C&C Red Alert 3	660M	635M	4.4M	1.6M
Age of Empire 3	245M	243M	2.7M	2.5M
Supreme Commander 2	1.2G	629M	2.5M	1.5M
Civilization IV + ext	340M	293M	2M	1.9M
Anno 1701	432M	413M	1.9M	1.8M
Warcraft 3	129M	124M	1.9M	1.8M

Network based maphack

Rewriting network traffic

- Resync the game or get caught
- Use LSP (Layer service provider) to rewrite network traffic

```
Administrator: C:\Windows\System32\cmd.exe - instlsp64.exe -p
Winsock 32-bit Catalog:
=====
2620 - vlsplListener over [RSUP TCP Service Provider]
2621 - vlsplListener over [MSAFD Tcpip [TCP/IP]]
2622 - vlsplListener over [MSAFD Tcpip [UDP/IP]]
2623 - vlsplListener over [MSAFD Tcpip [RAW/IP]]
2624 - vlsplListener over [MSAFD Tcpip [TCP/IPv6]]
2625 - vlsplListener over [MSAFD Tcpip [UDP/IPv6]]
2626 - vlsplListener over [MSAFD Tcpip [RAW/IPv6]]
2627 - vlsplListener over [RSUP TCPv6 Service Provider]
2628 - vlsplListener over [RSUP UDPv6 Service Provider]
2629 - vlsplListener over [RSUP UDP Service Provider]
2630 - vlsplListener over [MSAFD Pgm (RDM)]
2631 - vlsplListener over [MSAFD Pgm (Stream)]
2632 - vlsplListener over [UMCI sockets DGRAM]
2633 - vlsplListener over [UMCI sockets STREAM]
1008 - RSUP TCP Service Provider
1001 - MSAFD Tcpip [TCP/IP]
1002 - MSAFD Tcpip [UDP/IP]
1003 - MSAFD Tcpip [RAW/IP]
1004 - MSAFD Tcpip [TCP/IPv6]
1005 - MSAFD Tcpip [UDP/IPv6]
1006 - MSAFD Tcpip [RAW/IPv6]
1007 - RSUP TCPv6 Service Provider
1009 - RSUP UDPv6 Service Provider
1010 - RSUP UDP Service Provider
1011 - MSAFD Pgm (RDM)
1012 - MSAFD Pgm (Stream)
1019 - UMCI sockets DGRAM
1020 - UMCI sockets STREAM
2605 - vlsplListener
Press any key to continue...

C:\svn\project\lsp\trunk\lsp\bin>instlsp64.exe -p
Winsock 64-bit Catalog:
=====
2606 - vlsplListener over [RSUP TCP Service Provider]
2607 - vlsplListener over [MSAFD Tcpip [TCP/IP]]
2608 - vlsplListener over [MSAFD Tcpip [UDP/IP]]
2609 - vlsplListener over [MSAFD Tcpip [RAW/IP]]
2610 - vlsplListener over [MSAFD Tcpip [TCP/IPv6]]
2611 - vlsplListener over [MSAFD Tcpip [UDP/IPv6]]
2612 - vlsplListener over [MSAFD Tcpip [RAW/IPv6]]
2613 - vlsplListener over [RSUP TCPv6 Service Provider]
2614 - vlsplListener over [RSUP UDPv6 Service Provider]
2615 - vlsplListener over [RSUP UDP Service Provider]
2616 - vlsplListener over [MSAFD Pgm (RDM)]
2617 - vlsplListener over [MSAFD Pgm (Stream)]
2618 - vlsplListener over [UMCI sockets DGRAM]
2619 - vlsplListener over [UMCI sockets STREAM]
1008 - RSUP TCP Service Provider
1001 - MSAFD Tcpip [TCP/IP]
1002 - MSAFD Tcpip [UDP/IP]
1003 - MSAFD Tcpip [RAW/IP]
1004 - MSAFD Tcpip [TCP/IPv6]
1005 - MSAFD Tcpip [UDP/IPv6]
1006 - MSAFD Tcpip [RAW/IPv6]
1007 - RSUP TCPv6 Service Provider
1009 - RSUP UDPv6 Service Provider
1010 - RSUP UDP Service Provider
1011 - MSAFD Pgm (RDM)
1012 - MSAFD Pgm (Stream)
1013 - UMCI sockets DGRAM
1014 - UMCI sockets STREAM
2604 - vlsplListener
Press any key to continue...
```

Understanding the network traffic

Understanding the network traffic



Bucket

Understanding the network traffic



Bucket



Visualize

Understanding the network traffic



Bucket



Visualize



Understand

Understanding the network traffic



Bucket



Visualize



Understand



Resync

Civilization 4 vizualization

The image shows a screenshot of the game 'Civilization IV: Beyond The Sword' with a network analysis tool, 'networkUI', overlaid on the bottom. The game interface shows a turn of 2 - 392 and a score of 0. The networkUI interface includes a 'Server Control' section with 'Start' and 'Stop' buttons, and a table of listening ports. The 'Rules' section has a dropdown menu set to 'Equal' and an 'Add' button. The 'Record' section has 'Record', 'Stop', and 'Clear' buttons, and a table of recorded data. A vertical visualization bar on the right side of the networkUI shows a colorful, pixelated pattern.

Server Control

Start Stop

listening ports

Port Packet Count

2056	3016
------	------

Rules

0 Equal Add

Name	Offset	Type	Match	Action	To	Size
------	--------	------	-------	--------	----	------

Record

Record Stop Clear Before After

Size	Recorded	Isolate Change	Count unchanged	Visualize
Size:11	561	Isolate	6	(o o)
Size:37	1965	Isolate	26	(o o)
Size:10	19	Isolate	10	(o o)
Size:29	2	Isolate	29	(o o)
Size:5	17	Isolate	5	(o o)

Civilization 4 vizualization

The image shows a screenshot of the game Civilization 4: Beyond the Sword. The game window is at the top, showing a map with a river and a city. Below the game window is a networkUI overlay. The overlay has a 'Server Control' section with 'Start' and 'Stop' buttons, and a table of listening ports. The table shows port 2056 with a packet count of 3016. An orange arrow points from the text 'LSP listener' below to the '2056' port entry. To the right of the 'Server Control' section is a 'Rules' section with a table for rule configuration. Below the 'Rules' section is a 'Record' section with a table of recorded packets. The table has columns for Size, Recorded, Isolate Change, Count unchanged, and Visualize. The 'Recorded' column has values 561, 1965, 19, 2, and 17. The 'Count unchanged' column has values 6, 26, 10, 29, and 5. The 'Visualize' column has buttons labeled '(o o)'. To the right of the networkUI overlay is a vertical visualization of the captured packets, showing a colorful, pixelated pattern of data.

networkUI

Server Control

Start Stop

listening ports

Port	Packet Count
2056	3016

Rules

Name	Offset	Type	Match	Action	To	Size
------	--------	------	-------	--------	----	------

Record Stop Clear

Size	Recorded	Isolate Change	Count unchanged	Visualize
Size:11	561	Isolate	6	(o o)
Size:37	1965	Isolate	26	(o o)
Size:10	19	Isolate	10	(o o)
Size:29	2	Isolate	29	(o o)
Size:5	17	Isolate	5	(o o)

LSP listener

Civilization 4 vizualization

The image shows a screenshot of the game 'Civilization IV: Beyond The Sword' in the top window, with a network visualization tool 'networkUI' overlaid on the bottom. The network tool has several sections:

- Server Control:** Includes 'Start' and 'Stop' buttons, and a table of listening ports.
- Rules:** A configuration area with a dropdown menu set to 'Equal' and an 'Add' button.
- Memory:** A table with columns for 'Address' and 'Value'.
- Record:** A table with columns for 'Size', 'Recorded', 'Isolate Change', 'Count unchanged', and 'Visualize'.
- Visualization:** A vertical bar on the right side of the network tool, showing a colorful, pixelated pattern representing network data.

Two orange arrows point to the 'Packet Count' column in the 'listening ports' table and the 'Record' table. The text 'LSP listener' is written in large orange letters, and 'Buckets' is written in large orange letters below it.

Port	Packet Count
2056	3016

Size	Recorded	Isolate Change	Count unchanged	Visualize
Size:11	561	Isolate	6	(o o)
Size:37	1965	Isolate	26	(o o)
Size:10	19	Isolate	10	(o o)
Size:29	2	Isolate	29	(o o)
Size:5	17	Isolate	5	(o o)

Civilization 4 vizualization

Bucket visualization →

LSP listener

Buckets

networkUI

Server Control

Start Stop

listening ports

Port Packet Count

2056	3016
------	------

Rules

Name	Offset	Type	Match	Action	To	Size
------	--------	------	-------	--------	----	------

Record Stop Clear

Size	Recorded	Isolate Change	Count unchanged	Visualize
Size:11	561	Isolate	6	(o o)
Size:37	1965	Isolate	26	(o o)
Size:10	19	Isolate	10	(o o)
Size:29	2	Isolate	29	(o o)
Size:5	17	Isolate	5	(o o)

Before After

Name	Size	Visualize
------	------	-----------

Civilization 4 vizualization

The image displays a network visualization tool for Civilization 4. The top section shows a game map with the text "Bucket visualization" and an arrow pointing to the right. Below the map is the "LSP listener" interface, which includes a "Server Control" section with "Start" and "Stop" buttons, and a table of listening ports. The "Packet Count" for port 2023 is 2010. Below this is a "Rules" section with a table for rule configuration and a "Record" section with a table of recorded data. The bottom right section shows a "Bucket visualization" with a vertical bar chart of colored segments.

Bucket visualization →

networkUI

Server Control

Start Stop

listening ports

Port Packet Count

2023 2010

↑

LSP listener

Rules

Name	Offset	Type	Match	Action	To	Size

Record Stop Clear

Size	Recorded	Isolate Change	Count unchanged	Visualize
Size 11	561	isolate	6	(o o)
Size 37	1965	isolate	26	(o o)
Size 10	19	isolate	10	(o o)
Size 29	2	isolate	29	(o o)
Size 5	17	isolate	5	(o o)

Before After

Name	Size	View

Scale << LU >>

Buckets

Civilization 4 vizualization

Bucket visualization →

networkUI

Server Control

Start Stop

listening ports

Port	Packet Count
2020	2010

↑

LSP listener

Memory Address Value

↑

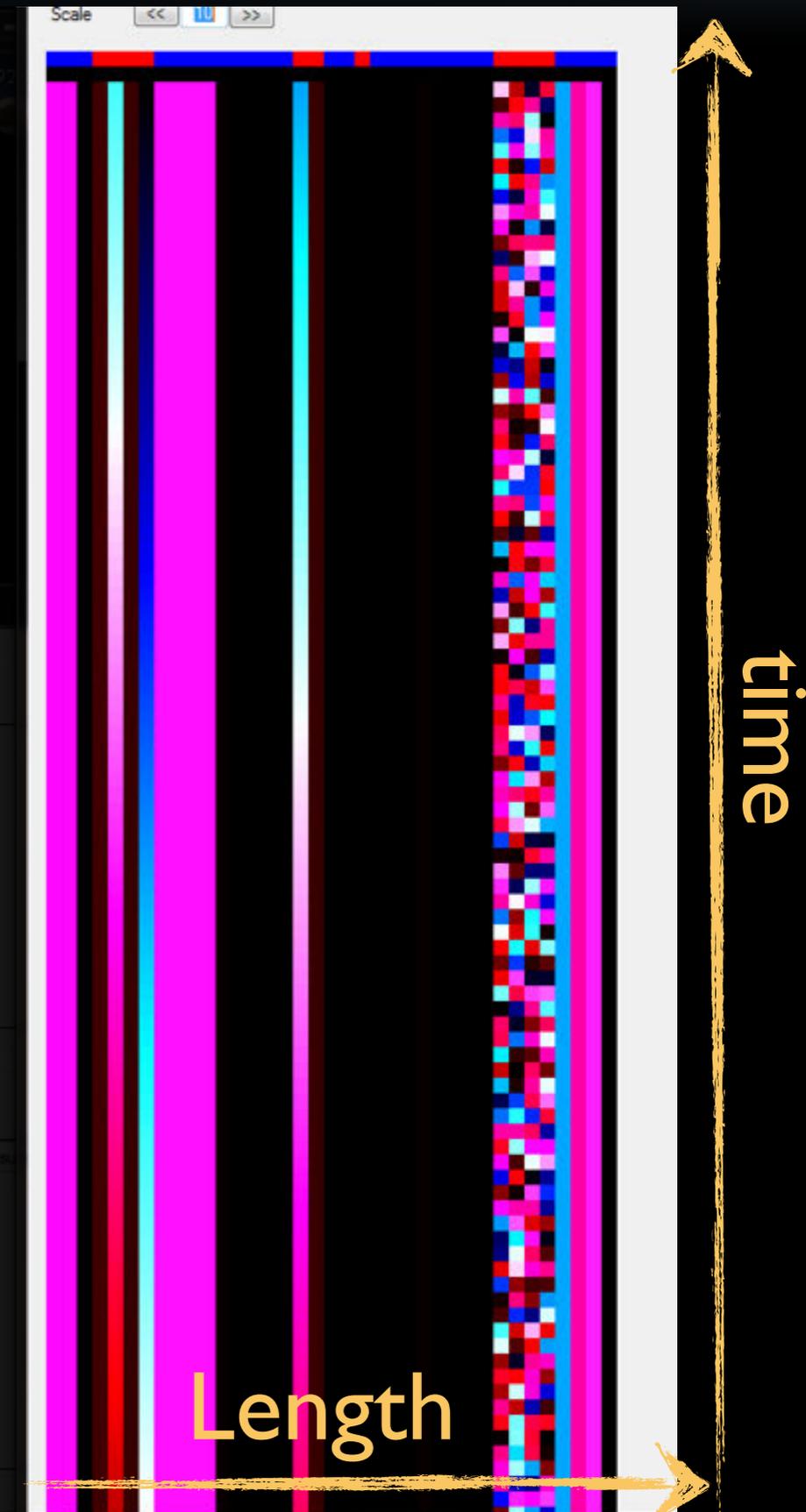
Buckets

Rules

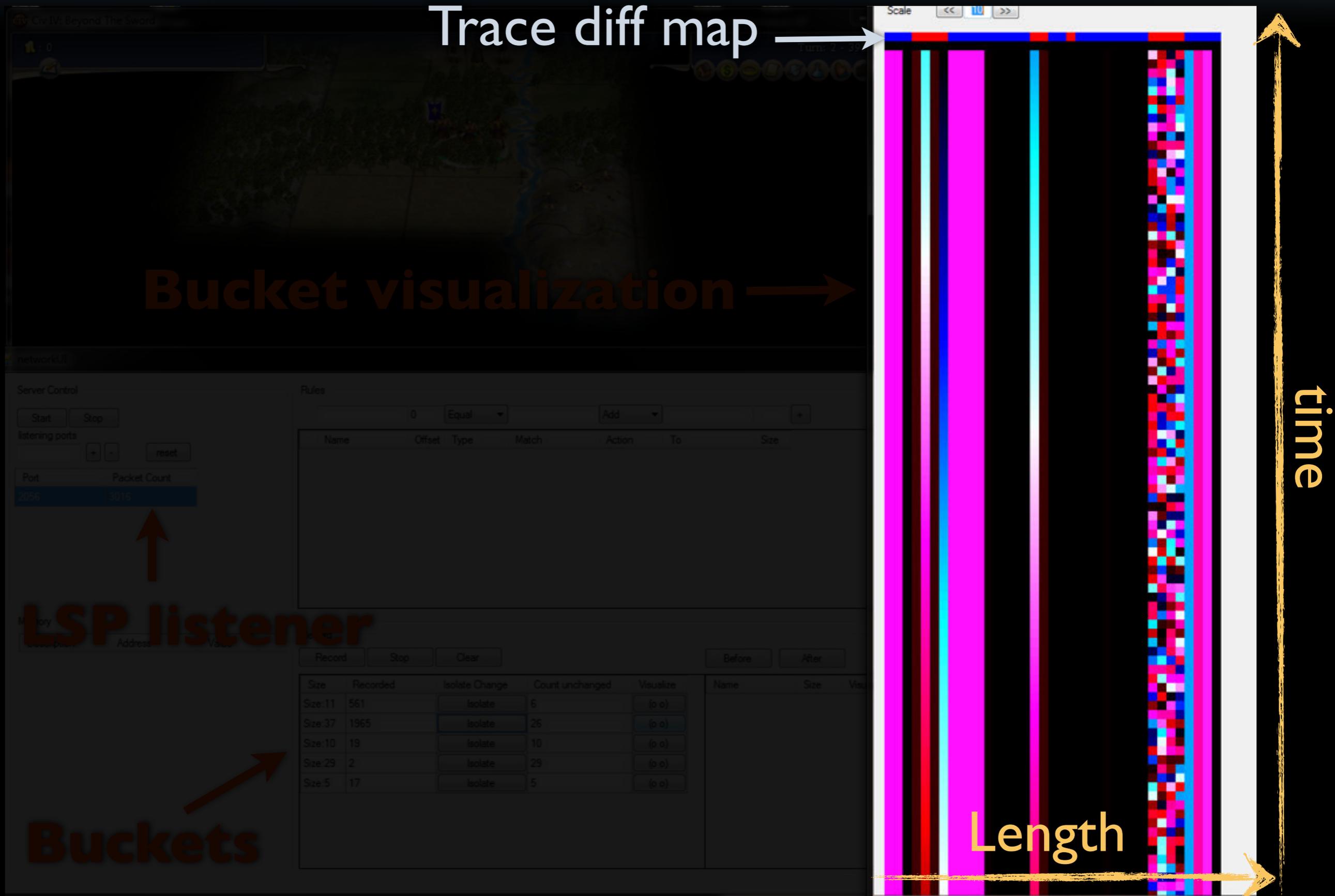
Name	Offset	Type	Match	Action	To	Size

Record Stop Clear

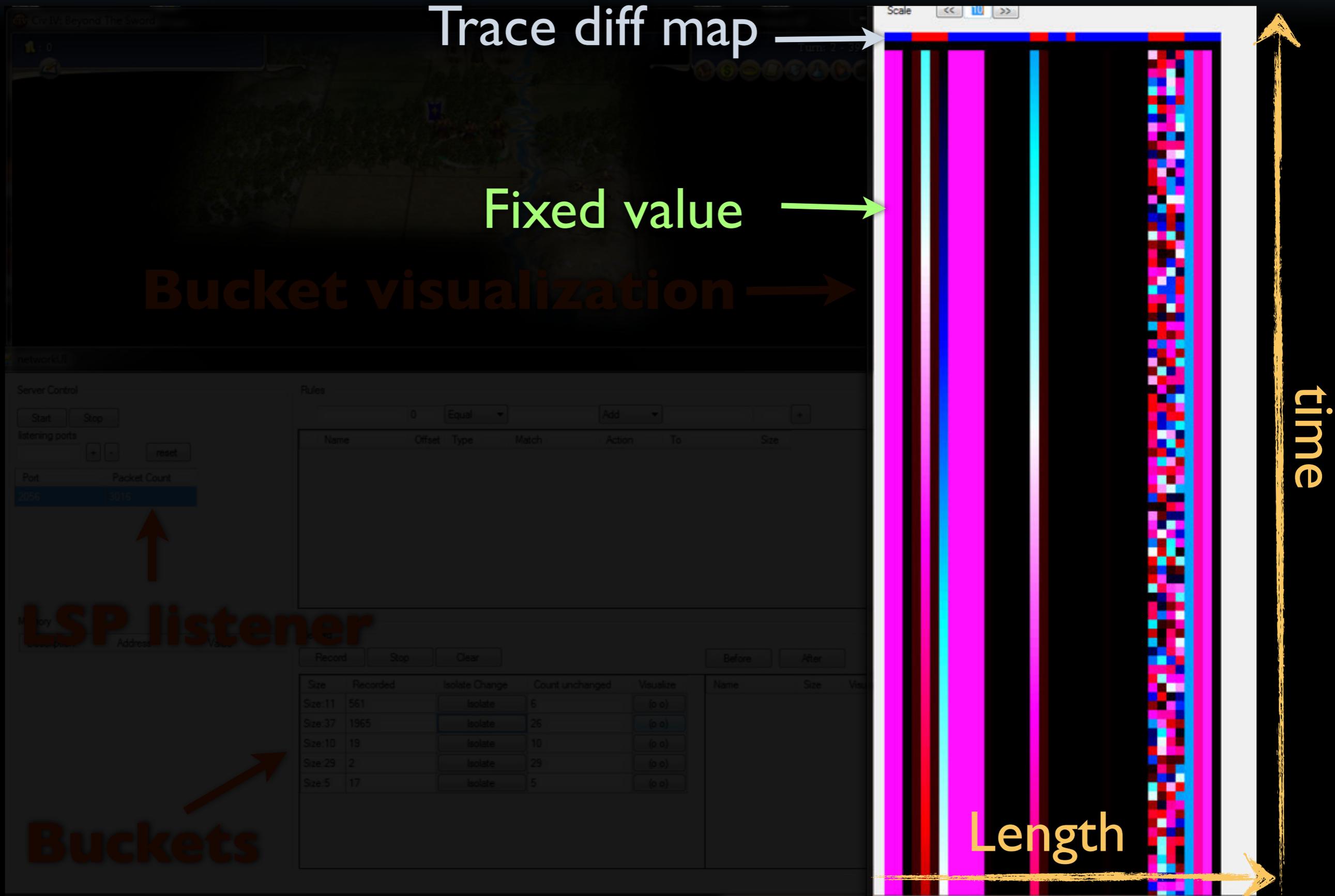
Size	Recorded	Isolate Change	Count unchanged	Visualize
Size 11	561	isolate	6	(o o)
Size 37	1965	isolate	26	(o o)
Size 10	19	isolate	10	(o o)
Size 29	2	isolate	29	(o o)
Size 5	17	isolate	5	(o o)



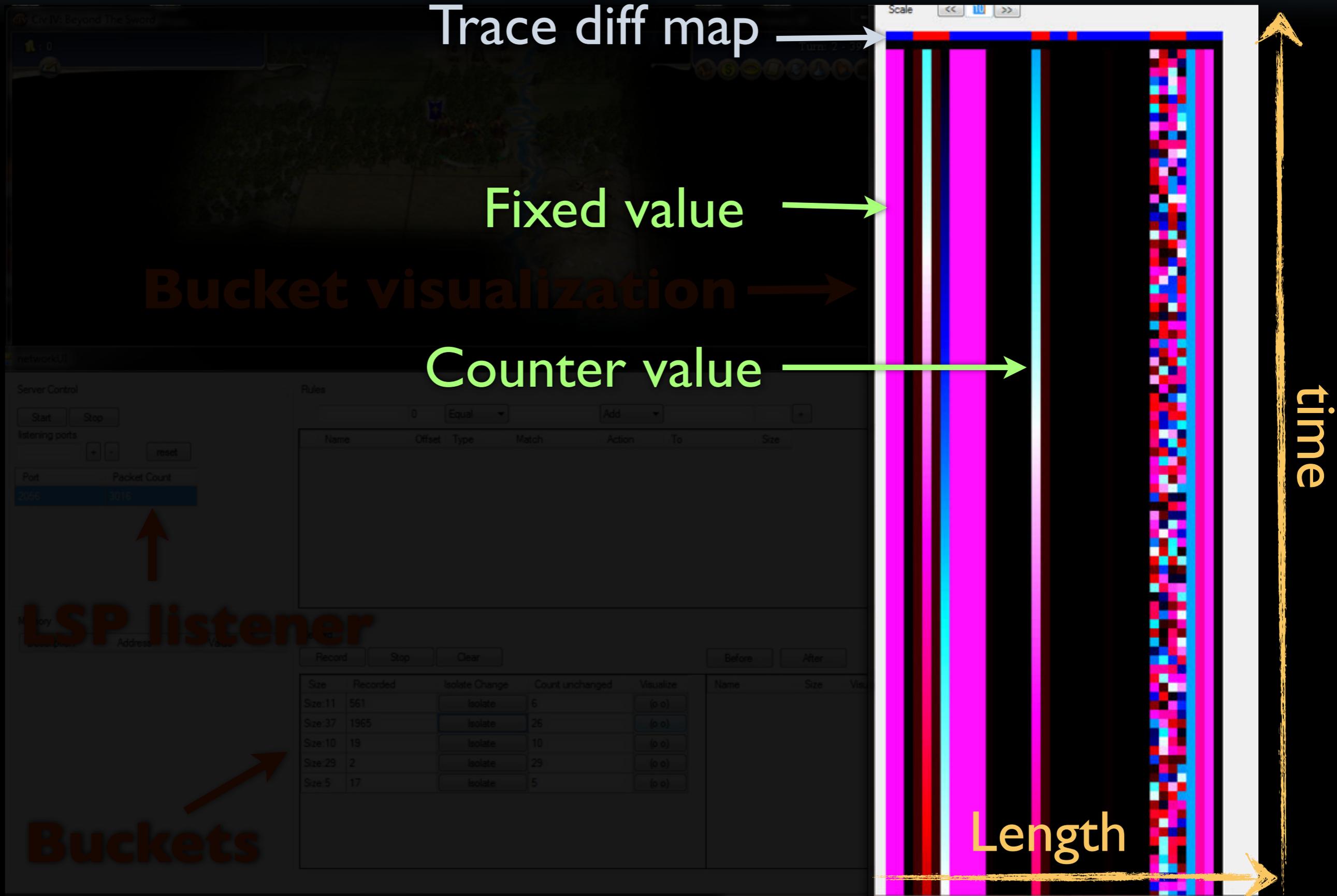
Civilization 4 vizualization



Civilization 4 visualization



Civilization 4 vizualization



Civilization 4 vizualization

