Computational Thinking

Temasek Junior College

Davin Choo

cxjdavin+CTC@gmail.com

TEMASEK
JUNIOR COLLEGE

Who am I?

- Ex-TJC Student (CG24/07)
  - IT Club Secretary
    (while it was under Mr Low Chang Hong)
- Currently in NUS
  - Computer Science and Mathematics DDP

Computational Thinking

- Logical Thinking
- Modelling
- Decomposition
- Pattern recognition
- Pattern generalisation
- Abstraction
- Algorithmic Thinking
- Efficiency

In-class Exercise

Travel Agency

Travel Agency

<u>Given</u>

A list of tourists, each with places they want to visit

<u>To do</u>

Charter bus rides for them so each tours get to see all of their places

Tourism Spots in Singapore

- Botanical Gardens
- Gardens by the Bay
- Marina Bay Sands
- Sentosa Island
- Jurong Bird Park
- Singapore Flyer
- Universal Studios SIngapore
- Clarke Quay

http://commons.wikimedia.org/wiki/File:Merlion_Sentosa.jpg

Tourists

- Amy
- Ben
- Charlie
- Dominic
- Emma
- Felicia
- Ginna
- Harry

Question

- Do location names matter?
- Do tourist names matter?
- Do tourist genders matter?

Tourism Spots in Singapore

- Botanical Gardens **[BG]**
- Gardens by the Bay **[GB]**
- Marina Bay Sands **[MBS]**
- Sentosa Island **[SI]**
- Jurong Bird Park **[JBP]**
- Singapore Flyer **[SF]**
- Universal Studios SIngapore **[USS]**
- Clarke Quay **[CQ]**

http://commons.wikimedia.org/wiki/File:Merlion_Sentosa.jpg

Tourists

- Amy **[A]**
- Ben **[B]**
- Charlie **[C]**
- Dominic **[D]**
- Emma **[E]**
- Felicia **[F]**
- Ginna **[G]**
- Harry **[H]**

Tourists' Plans

	BG	GB	MBS	SI	JBP	SF	USS	CQ
A	✓	✓			✓			
B	✓		✓					✓
C				✓		✓	✓	
D			✓			✓		✓
E		✓	✓					✓
F	✓	✓			✓			
G						✓		✓
H			✓					✓

Tourists' Plans

	BG	GB	MBS	SI	JBP	SF	USS	CQ
A	✓	✓			✓			
B	✓		✓					✓
C				✓		✓	✓	
D			✓			✓		✓
E		✓	✓					✓
F	✓	✓			✓			
G						✓		✓
H			✓					✓

Tourists' Plans

	BG	GB	MBS	SI	JBP	SF	USS	CQ
A	✓	✓			✓			
B	✓		✓					✓
C				✓		✓	✓	
D			✓			✓		✓
E		✓	✓					✓
F	✓	✓			✓			
G						✓		✓
H			✓					✓

Tourists’ Plans

	BG	GB	MBS	SI	JBP	SF	USS	CQ
A	✓	✓			✓			
B	✓		✓					✓
C				✓		✓	✓	
D			✓			✓		✓
E		✓	✓					✓
~~F~~	~~✓~~	~~✓~~			~~✓~~			
~~G~~						~~✓~~		~~✓~~
~~H~~			~~✓~~					~~✓~~

Solution #1

- Singapore 1-Day Tour
  - Put all tourists in 1 bus
  - Visit all 8 places in 1 day
- Pros
  - Works - 1 bus, 1 day
- Cons
  - Tourists unhappy: Too rushed. No time to see anything!

Solution #2

- Constraint 1: Each tourist visits at most 1 place/day
- Singapore Buffet-style tour
  - Schedule 8 buses to each location every day
  - Tourists pick which bus to take each day
- Pros
  - Works - At most 3 days to complete all plans
- Cons
  - Boss unhappy: Wasteful! 24 bus trips.

Solution #3

- Constraint 1: Each tourist visits at most 1 place/day
- Constraint 2: Send at most 1 bus to each place
- Singapore 8-day tour
  - Schedule 1 bus to a different location each day
  - Tourists pick which day to take the bus
- Pros
  - Works - At most 8 bus trips
- Cons
  - Tourists unhappy: 8 days needed. At least 5 wasted days

Moral of the Story

- Don’t work in a travel agency
- Just kidding
- Solutions to real world problems are affected by all stakeholders

Hands on

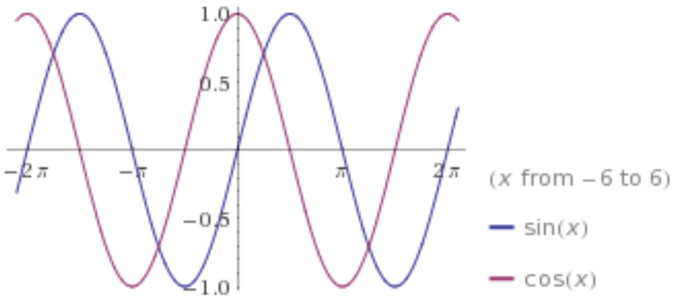
- Constraint 1: Each tourist visits at most 1 place/day
- Constraint 2: Send at most 1 bus to each place
- Constraint 3: Minimise number of days

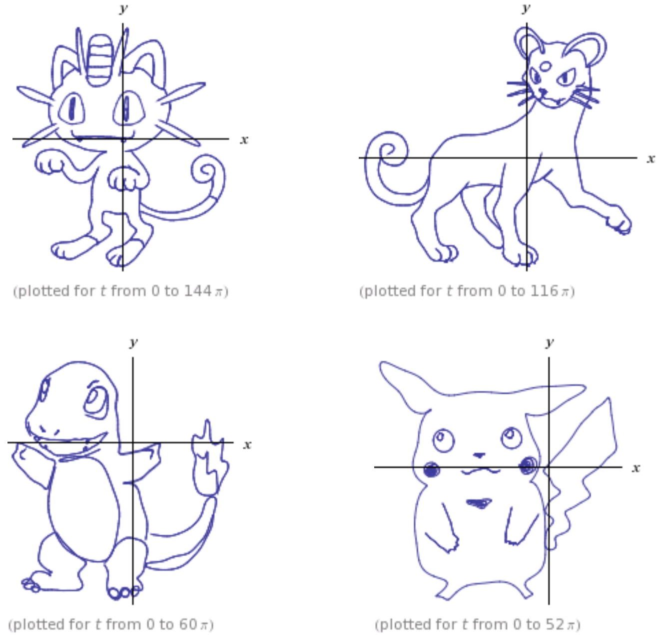
Hands on

- How many days did you use?
- How did you come up with the solution?
- What if I increase the number of attractions to 100?
- What if I increase the number of tourists to 100?

Graph Model Approach

- What is a graph?





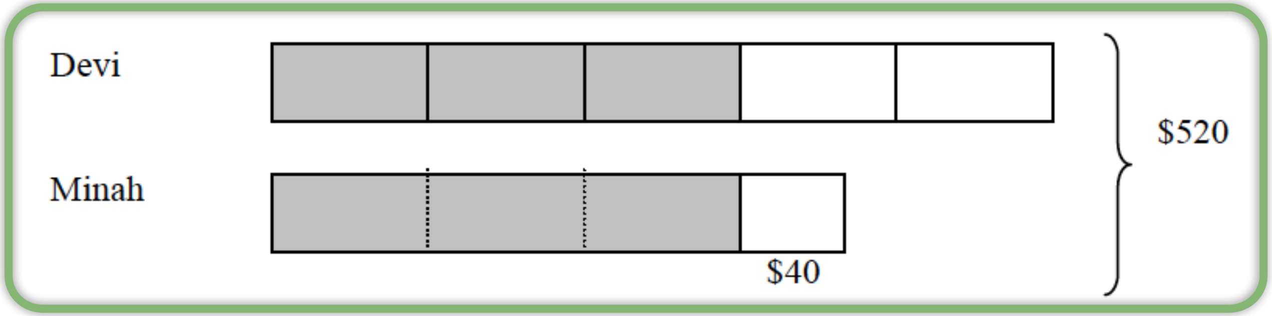
- Nope

http://www.wolframalpha.com/input/?i=sin+x%2C+cos+x
http://www.wolframalpha.com/input/?i=random+pokemon+curve

Graph Model Approach

- What is a model?

Devi and Minah have \$520 altogether. If Devi spends $\frac{2}{5}$ of her money and Minah spends \$40, then they will have the same amount of money left. How much money does Devi have? (Kho, 1987)



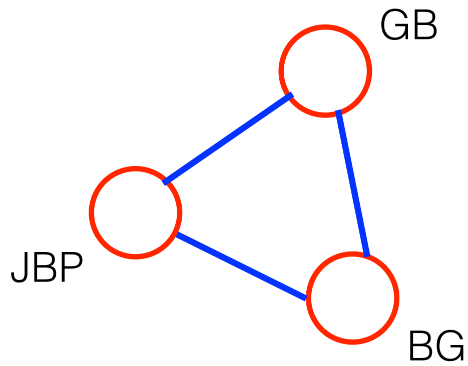
8 units = \$520 - \$40 = \$480
1 unit = \$480 ÷ 8 = \$60
Devi's money = 5 units
= 5 x \$60
= \$300

- Similar

http://math.nie.edu.sg/ame/matheduc/tme/tmeV6_2/05-Yan%20KC%20Final%20version.pdf

Graph Model Approach

- A mathematical model G = (V, E)
- Nodes/Vertices (V)
- Edges (E)
- In our case:
  - V = Attractions
  - E = Conflicts



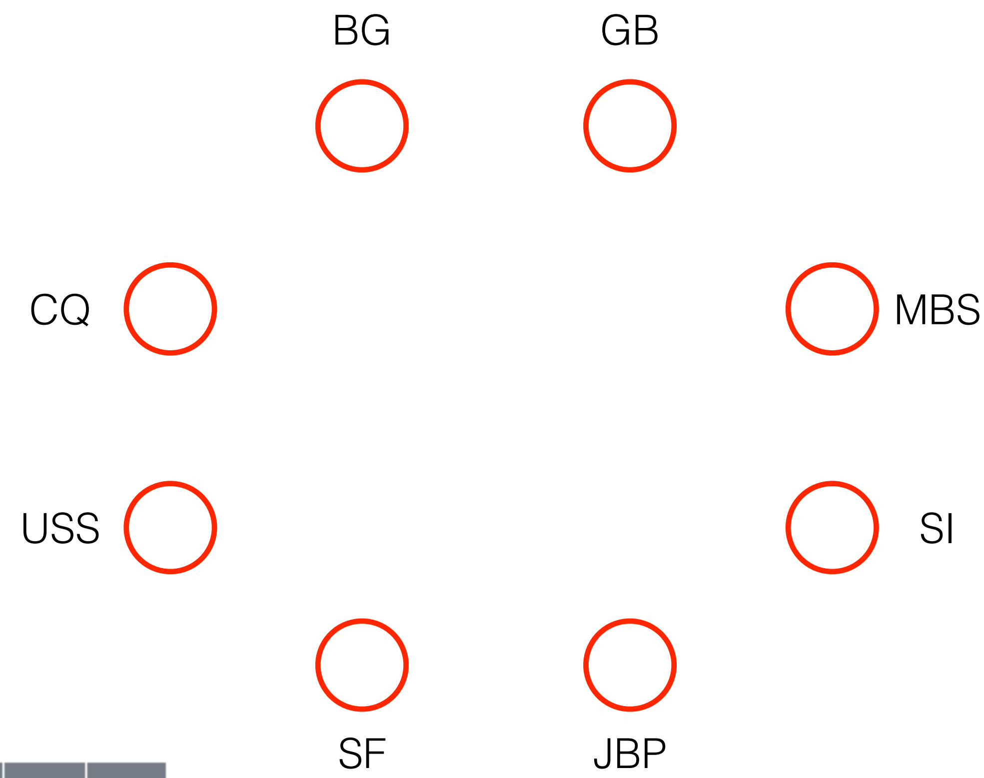
	BG	GB	MBS	SI	JBP	SF	USS	CQ
A	✓	✓			✓			

Hands on

Draw the constraint graph

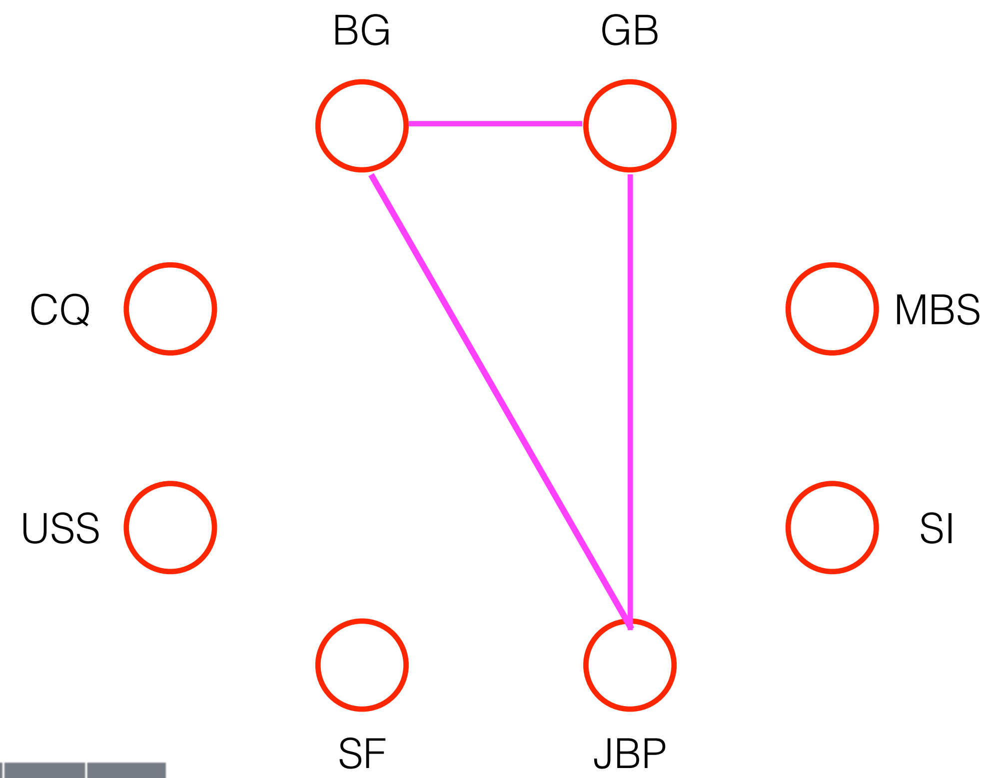
	BG	GB	MBS	SI	JBP	SF	USS	CQ
A	✓	✓			✓			
B	✓		✓					✓
C				✓		✓	✓	
D			✓			✓		✓
E		✓	✓					✓

Constraint Graph



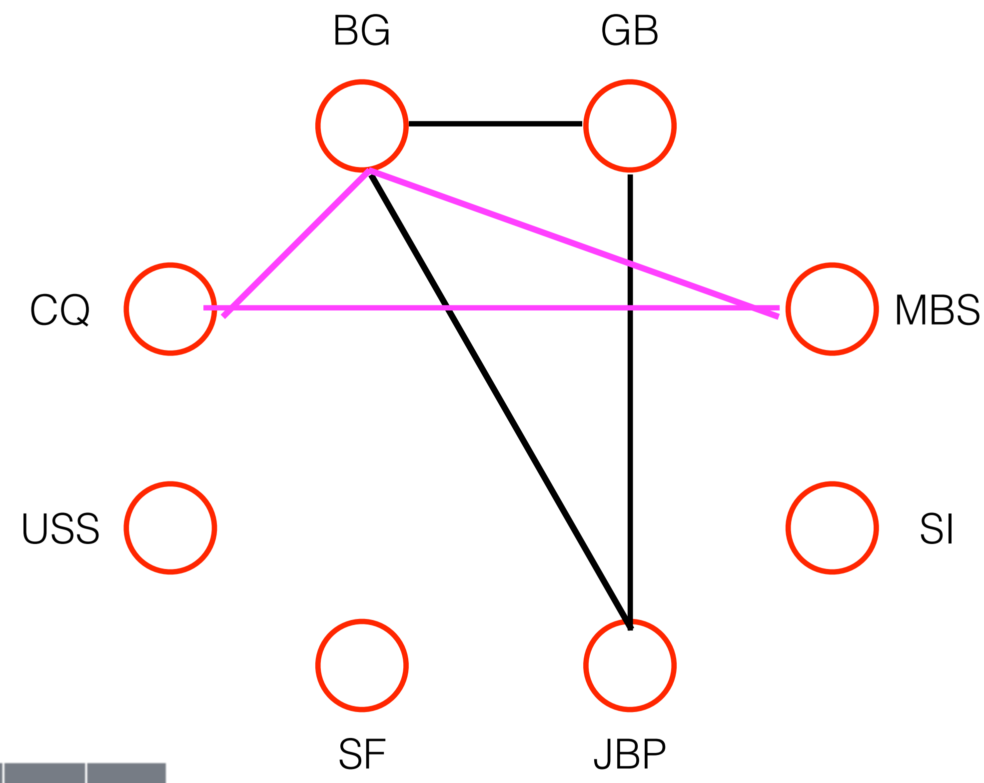
	BG	GB	MBS	SI	JBP	SF	USS	CQ
A	✓	✓			✓			
B	✓		✓					✓
C				✓		✓	✓	
D			✓			✓		✓
E		✓	✓					✓

Constraint Graph



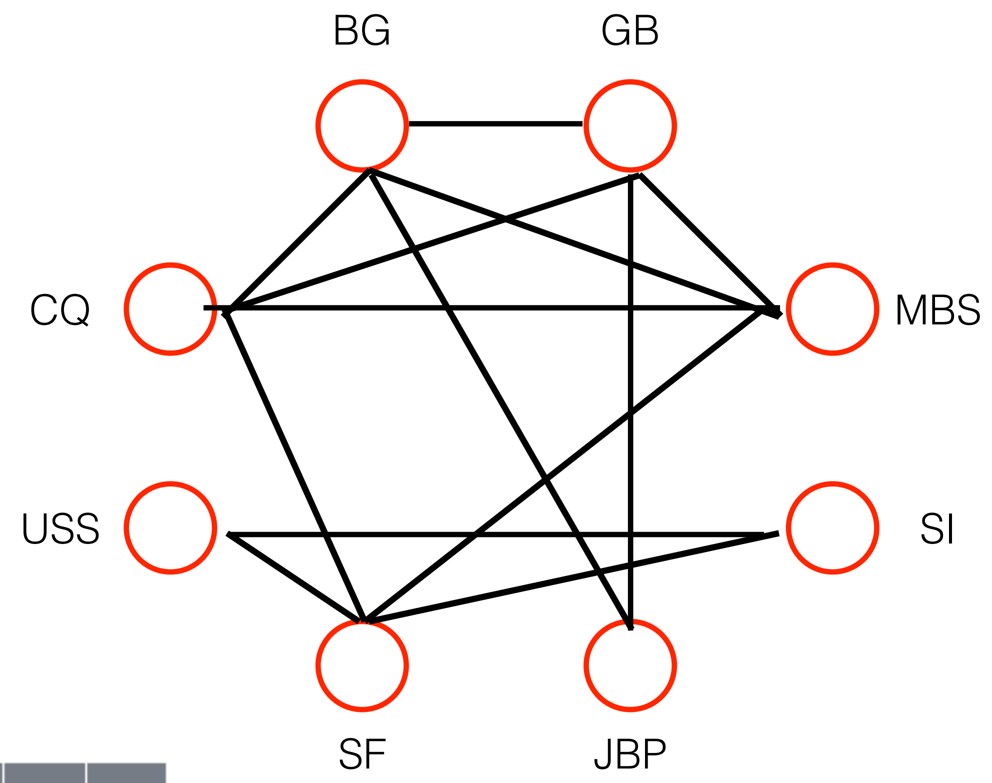
	BG	GB	MBS	SI	JBP	SF	USS	CQ
A	✓	✓			✓			
B	✓		✓					✓
C				✓		✓	✓	
D			✓			✓		✓
E		✓	✓					✓

Constraint Graph



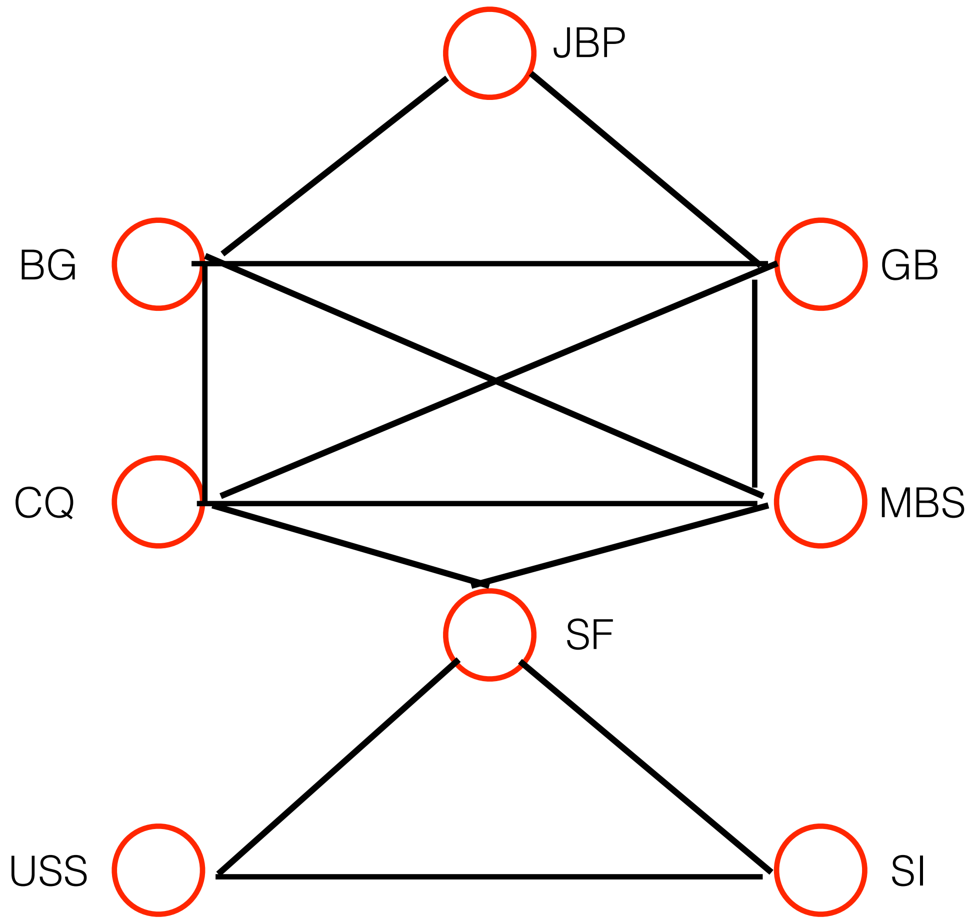
	BG	GB	MBS	SI	JBP	SF	USS	CQ
A	✓	✓			✓			
B	✓		✓					✓
C				✓		✓	✓	
D			✓			✓		✓
E		✓	✓					✓

Constraint Graph



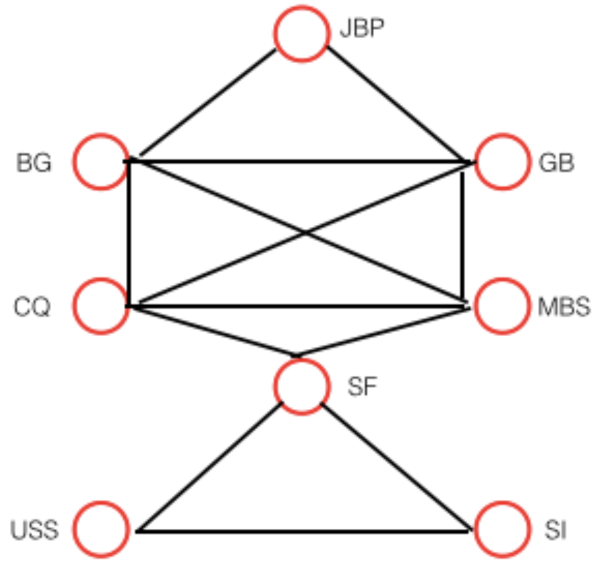
	BG	GB	MBS	SI	JBP	SF	USS	CQ
A	✓	✓			✓			
B	✓		✓					✓
C				✓		✓	✓	
D			✓			✓		✓
E		✓	✓					✓

Re-arranging…

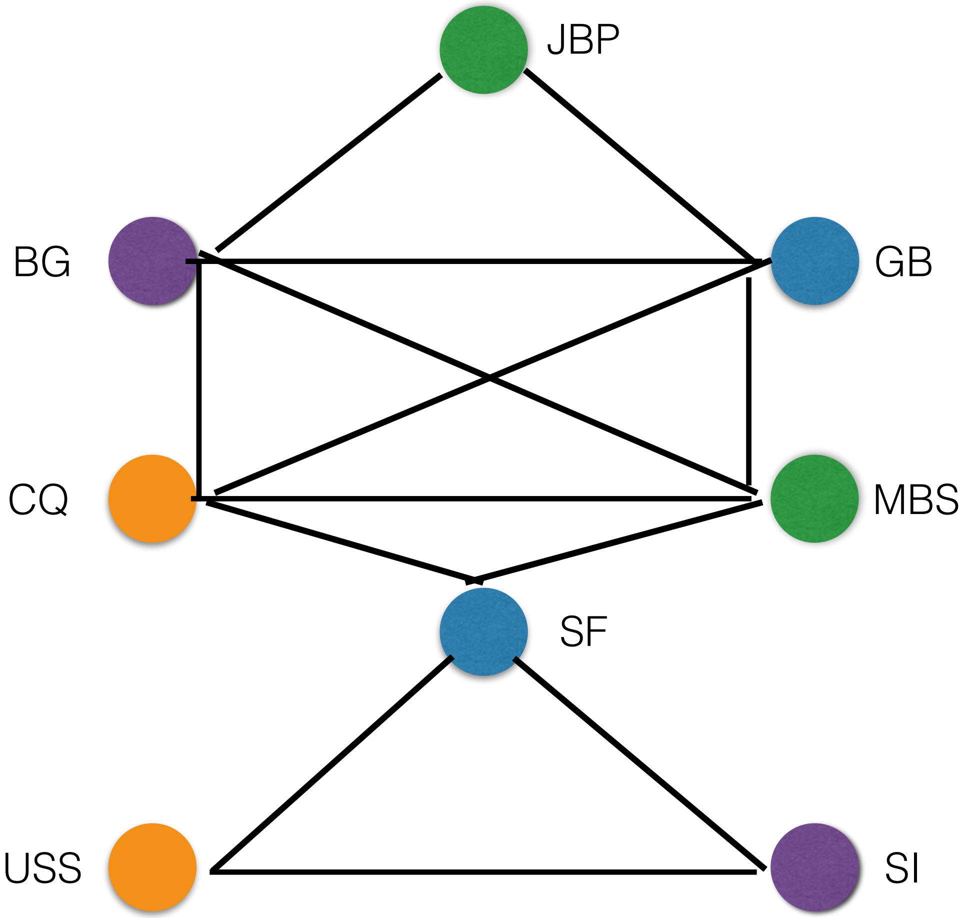


Graph Model

- Usage
  - Easy to read constraint
  - (Or the lack of it)
- Claim
  - Colour the vertices. Adjacent vertices not same colour
  - # colours used = # days needed
  - Same color = Visit on same day



Possible solution



Day 1 - JBP, MBS

Day 2 - BG, SI

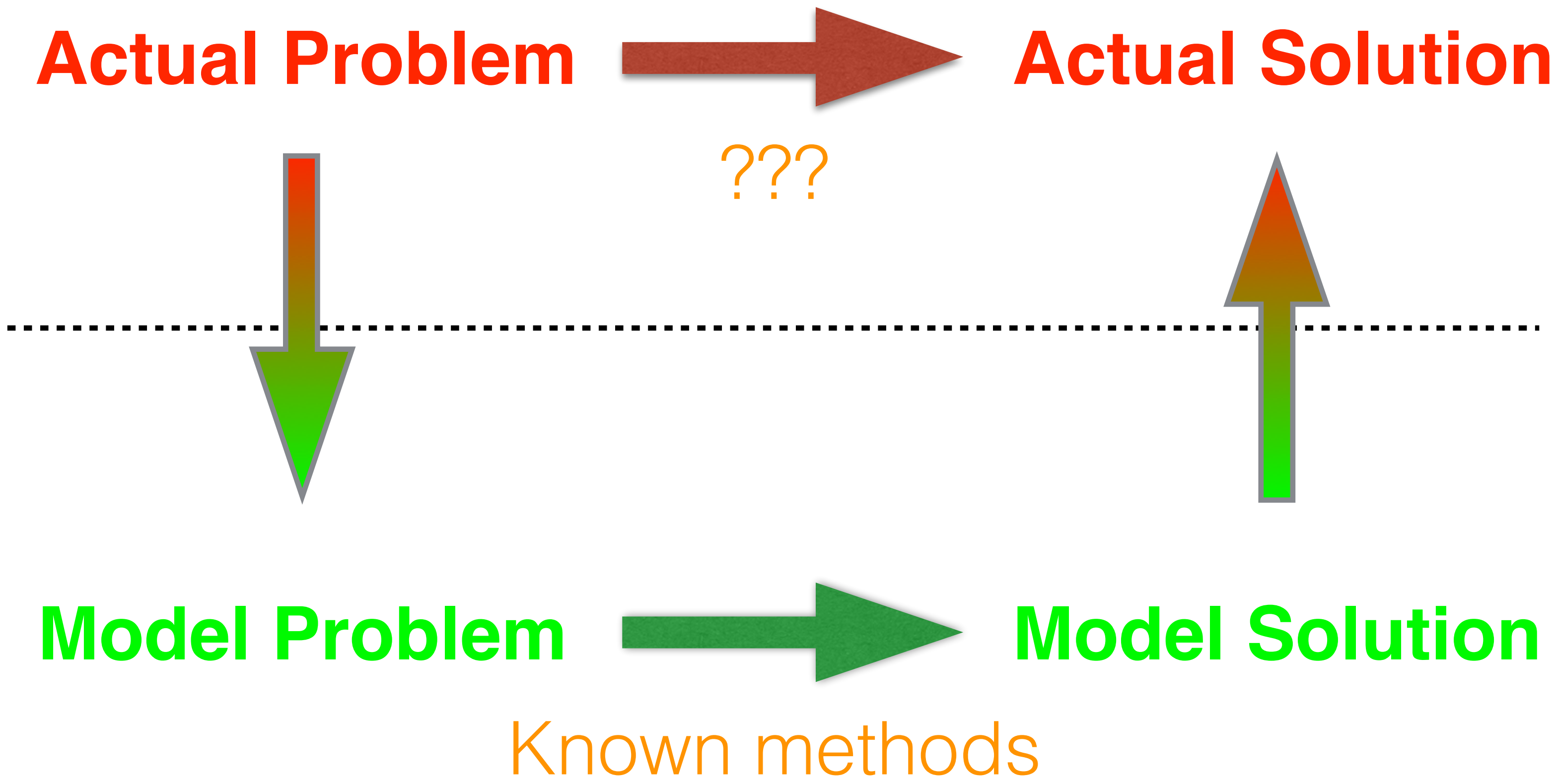
Day 3 - CQ, USS

Day 4 - GB, SF

Questions

- Does the ordering of the colours matter?
- How do we get the list of tourists on each bus?

Models


Actual Problem
Actual Solution
???
Model Problem
Model Solution
Known methods

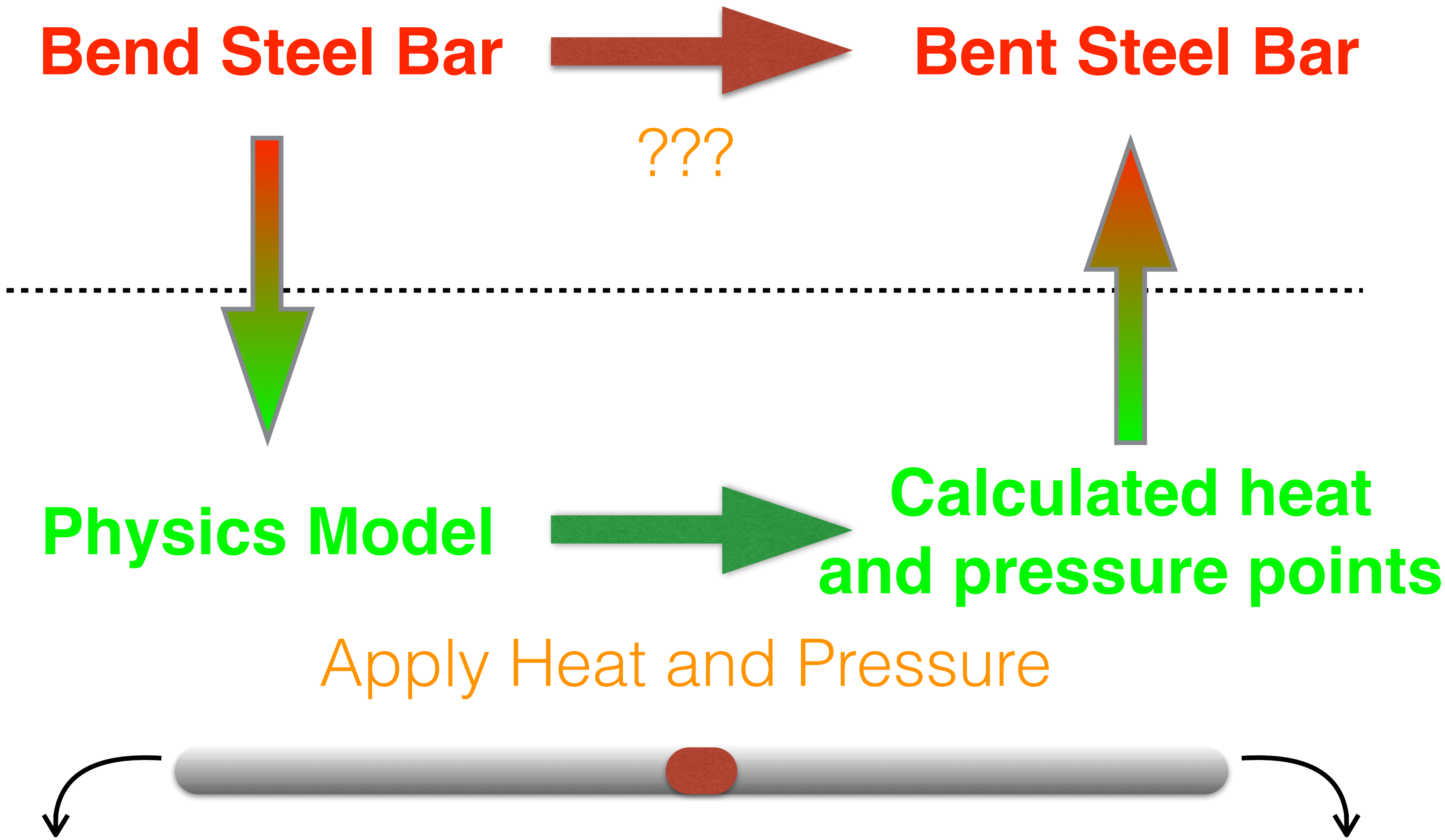
Models

Bend Steel Bar → **Bent Steel Bar**

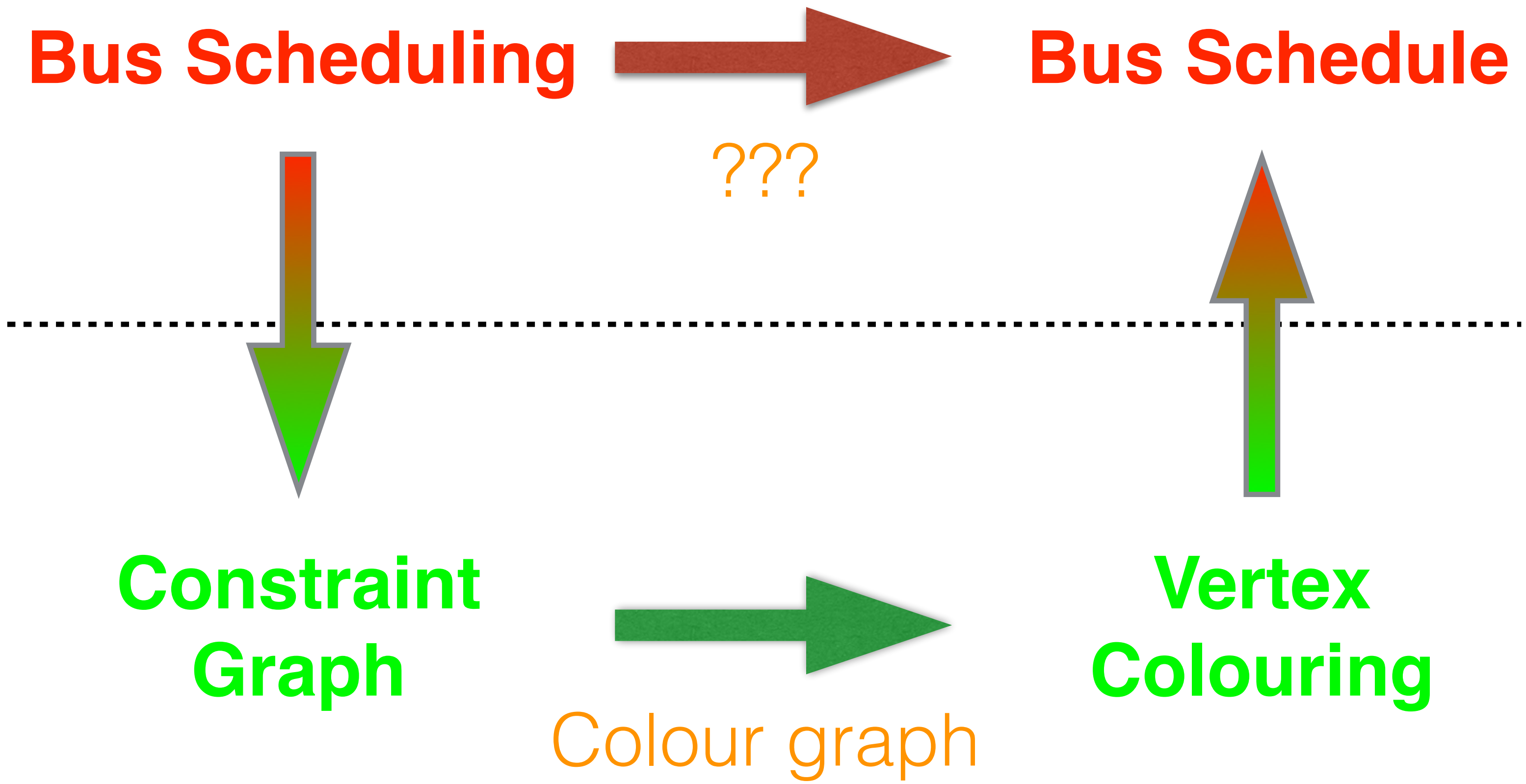
???

http://youtu.be/MkibO5PdAil?t=29s

Models


Bend Steel Bar
Bent Steel Bar
???
Physics Model
Calculated heat
and pressure points
Apply Heat and Pressure

Models


Bus Scheduling
Bus Schedule
???
Constraint Graph
Vertex Colouring
Colour graph

Exam Scheduling

<u>Given</u>

A list of students, each with subjects that they take

<u>To do</u>

Plan the exam times and dates for the school

Fighting fish

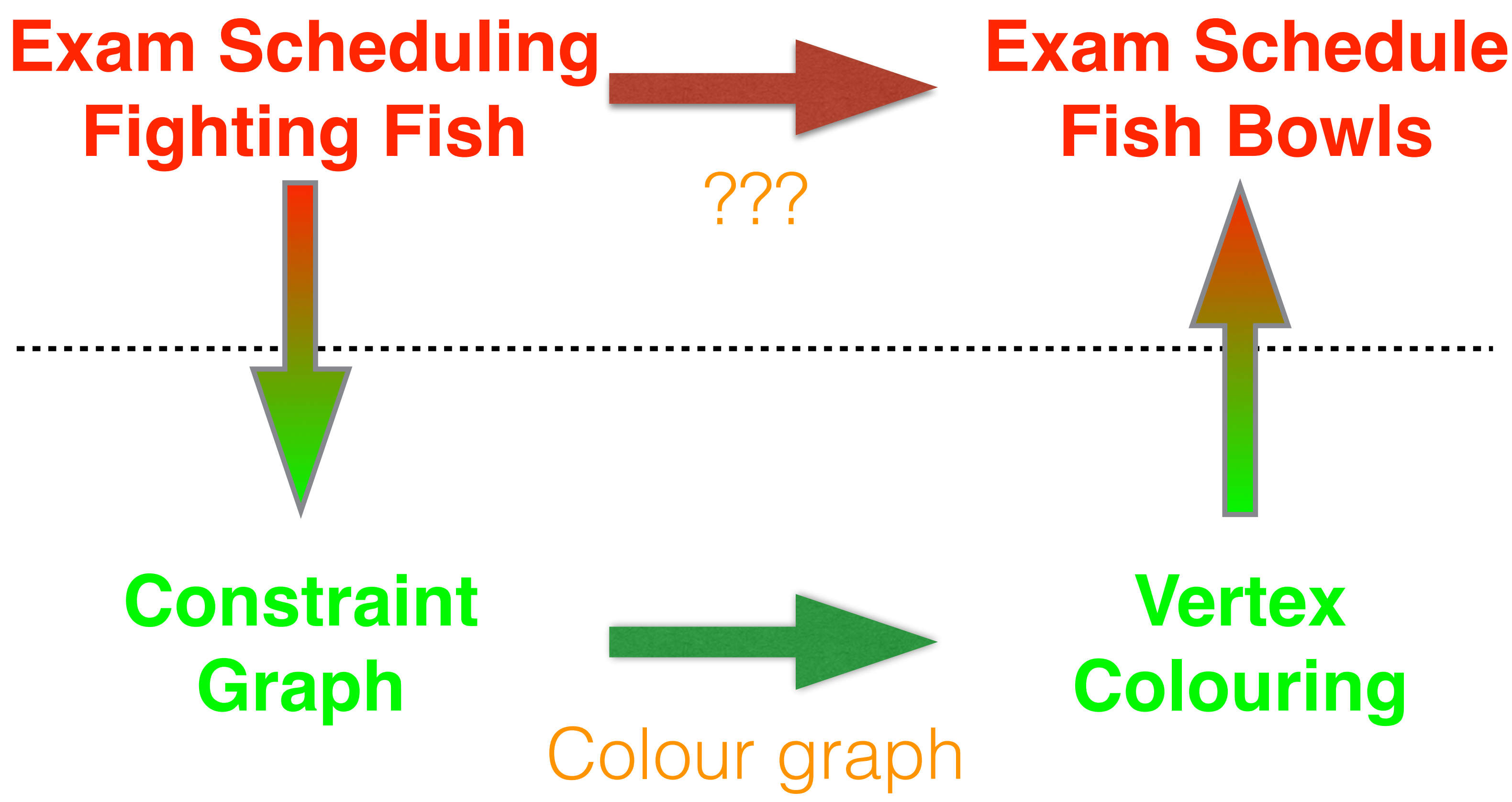
Given

A list of fish, each with a list of other fish which they will fight with

To do

Use as little bowls to hold all the fish

Models



Exam Scheduling
Fighting Fish
???
Exam Schedule
Fish Bowls
Constraint
Graph
Colour graph
Vertex
Colouring

Math to Wolfram

Conrad Wolfram

Conrad Wolfram is a British technologist and businessman known for his work in information technology and its application. Wikipedia

Born: June 10, 1970 (age 43), Oxford, United Kingdom

Siblings: Stephen Wolfram

Education: University of Cambridge, Eton College, Dragon School

What is math?

1. Posing the right questions
2. Real world ⟶ math formulation
3. Computation
4. Math formulation ⟶ real world, verification

http://www.wolframalpha.com

Wolfram’s TED talk

19min 19sec

Lessons Learnt

- Abstraction
  - Remove useless information that don’t help in solving the problem (e.g. names)
- Simplify if possible
- Real world problems are usually subject to many constraints
- Models are helpful
  - Grants you access to well-known problems/solutions

Palindromes

- What are palindromes?
  - It is the **same** thing when you read it both forwards and backwards
- Are these strings palindromes?
  - 121
  - ASDF
  - ASDFDSA
  - 1

Homework

1) Palindromes

Given a string,
How do you check if it is a palindrome?

2) Read this and tell me the moral of the story:

http://www.comp.nus.edu.sg/~leonghw/Courses/cattywampus.html

If you are interested…

- Topics covered:
  - Abstraction
  - Modelling
  - Graph Theory
    - Graph colouring

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Homework

2) What is the moral of the Cattywampus story?

1) Palindromes

- It is the **same** thing when you read it both forwards and backwards

Given a string,
How do you check if it is a palindrome?

Discussion

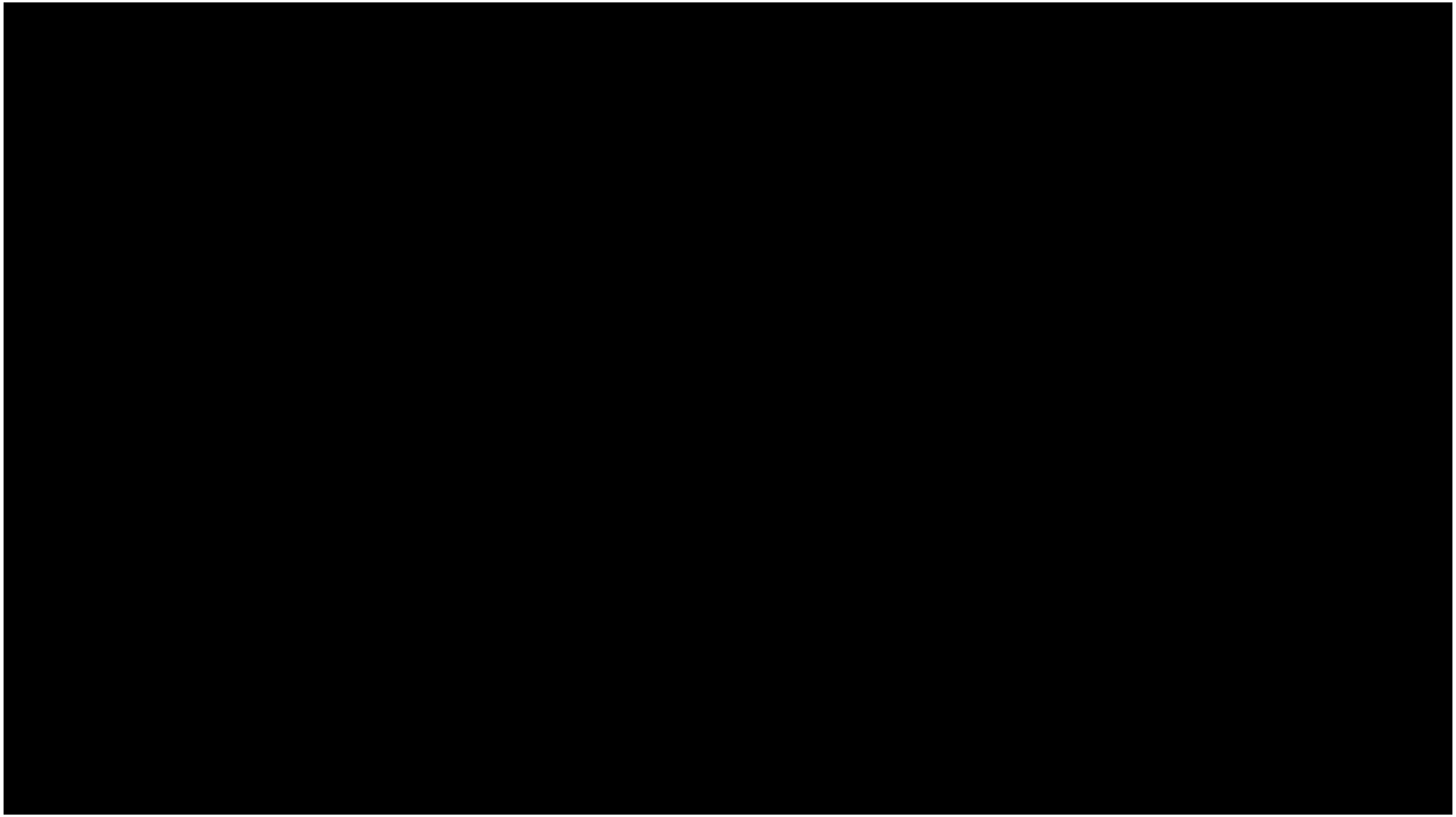
- Are the steps provided by your classmates unambiguous/clear?
- Can you use their steps to check if something is a palindrome? Let's try…

Next few sessions *might* feel like this

The Karate Kid (2010)
4min 19sec

https://www.youtube.com/watch?v=hkORWn_wbcY

But there are **good** reasons…



The Karate Kid (2010)
1min 53sec

https://www.youtube.com/watch?v=T10ycFr770g

Goal of next few sessions

- Teach you the basics and foundations (Important!)
- A step into understanding the world of Computer Science
- The core of Computer Science is “Algorithms”

Algorithms

- Google's definition

al·go·rithm
/ˈalgəˌriTHəm/

noun
noun: **algorithm**; plural noun: **algorithms**

1. a process or set of rules to be followed in calculations or other problem-solving operations, esp. by a computer.
   "a basic **algorithm for** division"

- Properties
  - Well defined (i.e. not ambiguous)
  - Finite/Fixed number of steps

Algorithm Examples

- Cooking

    1. Preheat oven to 350°C

    2. Sift together flour, cocoa, baking soda and 1 tsp salt

    3. Beat in eggs and vanilla

    4. …

Algorithm Examples

- Giving directions to a tourist (or Google Maps)

    1. Go straight until you reach “XXX Drive”
    2. Make a left turn and walk straight to bus stop #55423
    3. Take bus 42 for 9 stops
    4. …

What’s “wrong” with the examples?

- Too verbose
- Different people have different “levels of understanding”
- We need a model of how things(in our case, computers) work *before* we can provide an appropriate algorithm at a “suitable level”

Dijkstra’s algorithm

(Can you understand this?)

```
function Dijkstra(Graph, source):
    for each vertex v in Graph:                                  // Initializations
        dist[v]  := infinity ;                                   // Unknown distance function from
                                                                 // source to v
        previous[v]  := undefined ;                              // Previous node in optimal path
    end for                                                      // from source

    dist[source]  := 0 ;                                         // Distance from source to source
    Q := the set of all nodes in Graph ;                         // All nodes in the graph are
                                                                 // unoptimized – thus are in Q
    while Q is not empty:                                        // The main loop
        u := vertex in Q with smallest distance in dist[] ;      // Source node in first case
        remove u from Q ;
        if dist[u] = infinity:
            break ;                                              // all remaining vertices are
        end if                                                   // inaccessible from source

        for each neighbor v of u:                                // where v has not yet been
                                                                 // removed from Q.
            alt := dist[u] + dist_between(u, v) ;
            if alt < dist[v]:                                    // Relax (u,v,a)
                dist[v]  := alt ;
                previous[v]  := u ;
                decrease-key v in Q;                             // Reorder v in the Queue
            end if
        end for
    end while
    return dist;
endfunction
```

http://en.wikipedia.org/wiki/Dijkstra's_algorithm

Pseudocode

- “Language” of algorithms
- Used to describe an algorithm in
  “fairly standardised method” (there are variants)
- Similar to programming code but is
  programming language agnostic

Pseudocode

- Simple building blocks
    1. Numbering
    2. Comments
    3. Assignment
    4. Print/Return
    5. Conditionals (if-else)
    6. Repetition (while-loops)
    7. Function calls

1. Numbering

ALGORITHM_A (<Inputs>)

1. Do A
2. Do B
3. Do C

END

2. Comments

ALGORITHM_A (<Inputs>)

1. Do A // This helps others

2. Do B // to understand

3. Do C // what you wrote

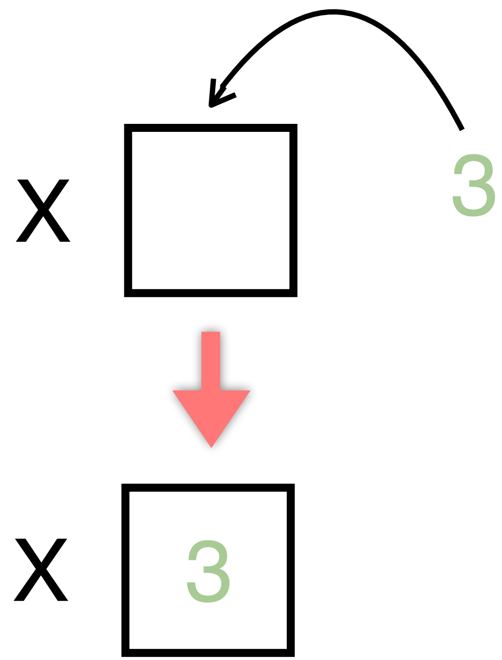
END

3. Assignment

ALGORITHM_A (<Inputs>)

1. X ← 3
2. Do B
3. Do C

END



4. Print/Return

PLUS_ONE (A)

1. X ← 1 + A
2. PRINT “Hello”
3. RETURN X

END

<u>Example:</u>
PLUS_ONE(2)

Shows: “Hello”
Returned: 3

Just visual display. Cannot be used further

Can still be used

<u>Question:</u>
PLUS_ONE(PLUS_ONE(2)) returns ____?

5. Conditionals

If ___Condition___, then ___Condition is met___

Otherwise, ___Condition not met___

5. Conditionals

If it rains today, then Natalie will bring umbrella

Otherwise, Natalie will wear sunglasses

5. Conditionals

If Yun Feng is hungry, then Yun Feng will eat

Otherwise, <Blank>

5. Conditionals

Condition

IS_EVEN (N)

1. IF (A % 2 == 0)
2. RETURN TRUE
3. ELSE
4. RETURN FALSE
5. END IF

END

X == Y
returns TRUE, if X is equal to Y
returns FALSE, otherwise

<u>Convention (Why == instead of =)</u>
In programming, = denotes ←

<u>Example</u>:

IS_EVEN (5) returns ___?

IS_EVEN (4) returns ___?

5. Conditionals

<u>Nested Conditionals</u>

Condition 1 Condition 2

If (A and B), then ____.

If (A and ¬B), then ____.

Otherwise (i.e. ¬A), ____.

5. Conditionals

```
NESTED_IF_ALGO ()
1.  IF (A)
2.      IF (B)
3.          ____
4.      ELSE
5.          ____
6.      END IF
7.  ELSE
8.      ____
9.  END IF
END
```

Check Conditional 2

6. Repetition

```
SAY_HI_N_TIMES (N)
    WHILE (N != 0)
        PRINT "HI"
        N ← N - 1
    END WHILE
END
```

Condition

X != Y
returns TRUE, if X is <u>not</u> equal to Y
returns FALSE, otherwise

<u>Convention</u>
! represents "not"/negation

<u>Example</u>:

SAY_HI_N_TIMES (1) returns ___?

SAY_HI_N_TIMES (5) returns ___?

SAY_HI_N_TIMES (-1) returns ___?

6. Repetition

```
SAY_HI_N_TIMES (N)
    WHILE (N > 0)
        PRINT "HI"
        N ← N - 1
    END WHILE
END
```

Condition

Choice of condition MATTERS!

<u>Example</u>:

SAY_HI_N_TIMES (1) returns ___?

SAY_HI_N_TIMES (5) returns ___?

SAY_HI_N_TIMES (-1) returns ___?

6. Repetition

SAY_HI_N_TIMES (N)

1. WHILE (N ≥ 1)
2. PRINT “HI”
3. N ← N - 1
4. END WHILE

END

Condition

Assumption MATTERS!

(N != 0)
vs.
(N > 0)
vs.
(N ≥ 1)

Example:

SAY_HI_N_TIMES (1) returns ___?

SAY_HI_N_TIMES (5) returns ___?

SAY_HI_N_TIMES (-1) returns ___?

Math Joke

- An empty kettle is <u>on the stove</u>, how do you boil water?

- An empty kettle is <u>on the floor</u>, how do you boil water?

7. Function Calls

```
MAKE_EVEN (N)
1.    IF (!IS_EVEN(N))
2.        RETURN (N + 1)
3.    ELSE
4.        RETURN N
5.    END IF
END
```

```
MAKE_EVEN (N)
1.    IF (!IS_EVEN(N))
2.        RETURN PLUS_ONE(N)
3.    ELSE
4.        RETURN N
5.    END IF
END
```

Learning Points

- Pick your conditions carefully
- Be lazy. Re-use previous solutions!
  - Don't repeat work
  - Don't reinvent the wheel
  - Unless your wheel is <u>better</u> (Prove it)
- Decompose/Break down large problems into smaller, more manageable parts

Dijkstra’s algorithm

(How about now?)

```
function Dijkstra(Graph, source):
    for each vertex v in Graph:                                  // Initializations
        dist[v]  := infinity ;                                    // Unknown distance function from
                                                                 // source to v
        previous[v]  := undefined ;                               // Previous node in optimal path
    end for                                                      // from source

    dist[source]  := 0 ;                                          // Distance from source to source
    Q := the set of all nodes in Graph ;                         // All nodes in the graph are
                                                                 // unoptimized – thus are in Q
    while Q is not empty:                                        // The main loop
        u := vertex in Q with smallest distance in dist[] ;      // Source node in first case
        remove u from Q ;
        if dist[u] = infinity:
            break ;                                              // all remaining vertices are
        end if                                                   // inaccessible from source

        for each neighbor v of u:                                // where v has not yet been
                                                                 // removed from Q.
            alt := dist[u] + dist_between(u, v) ;
            if alt < dist[v]:                                    // Relax (u,v,a)
                dist[v]  := alt ;
                previous[v]  := u ;
                decrease-key v in Q;                             // Reorder v in the Queue
            end if
        end for
    end while
    return dist;
endfunction
```

http://en.wikipedia.org/wiki/Dijkstra's_algorithm

Factorial

- Definition:
  - n! = n * (n-1) * (n-2) * … * 1
- Is there a pattern here?
  Can we break down the definition into smaller, easier parts?
  - 0! = 1, 1! = 1 ⟵ Base case
  - n! = n * (n-1)! ⟵ Recursive case

Hands on

- How would you implement Factorial in Pseudocode?

FACTORIAL(n)

- Example:
    - FACTORIAL(0) = 1
    - FACTORIAL(1) = 1
    - FACTORIAL(3) = 6

Recall:
n! = n * (n-1) * (n-2) * … * 1
n! = n * (n-1)!

Factorial

FACTORIAL(n)

1. result ← 1
2. WHILE (n ≥ 1)
3. result ← result * n
4. n ← n - 1
5. END WHILE
6. RETURN result

END

Question:
What if I change to > ?
Will it work?

Which definition is this using?

Can we use the other one?

Recall:
$n! = n * (n-1) * (n-2) * \ldots * 1$
$n! = n * (n-1)!$

Factorial

FACTORIAL(n)

<u>Question</u>:
What if I change to “AND” ?
Will it work?

1. IF (n == 0 OR n == 1)
2.   RETURN 1
3. ELSE
4.   RETURN n * FACTORIAL(n-1)
5. END IF

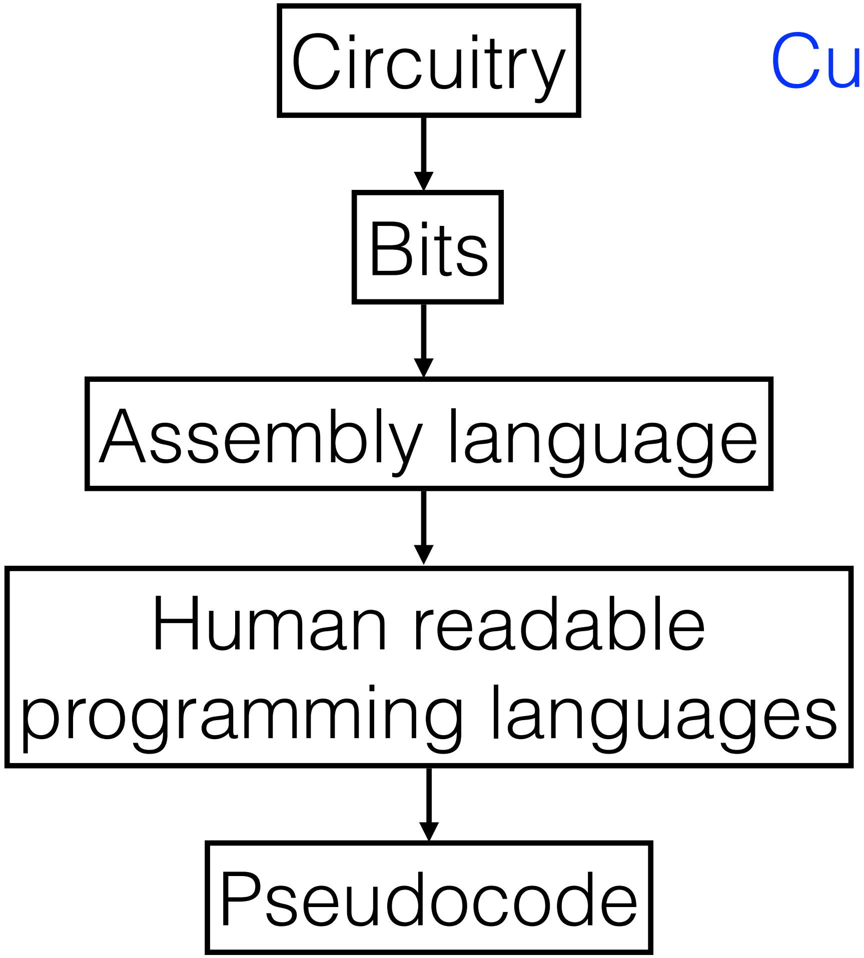
END

<u>Recall</u>:
n! = n * (n-1) * (n-2) * … * 1
n! = n * (n-1)!

Model of Computer

- No “intermediate” memory
  - Use variables (boxes) to hold data
- A single variable can hold 1 value
  - Overwritten when asked to store another value
- Instructions are executed sequentially
  (i.e. step by step, unless loop or function call)
- Index numbering start from 0 (why: Binary numbers)

Abstraction!



Current flows, resistors, NAND gates

0's and 1's (like in the Matrix)

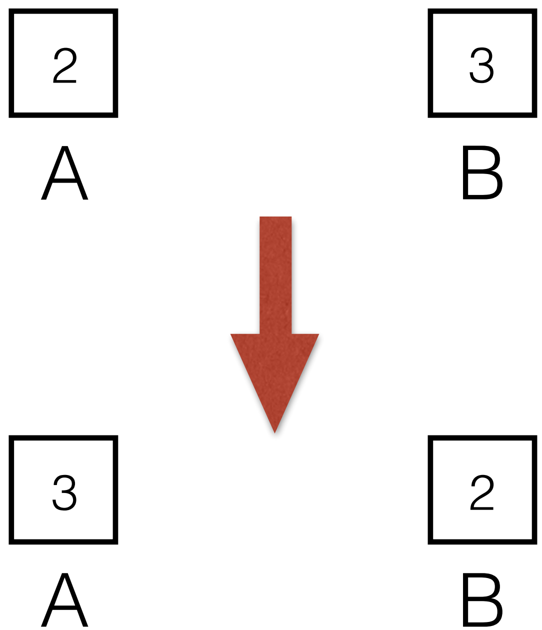
MIPS / ARM architecture
(PUSH, MOV, etc)

Java, C++, Python, JS, etc

What we are currently doing

SWAP

We want to swap the values of 2 variables,
how do we do it?



Sequences / Arrays

- A contiguous (joined-up) chain of variables (boxes)
- Values are referenced by 1 name (chain's name) and the index (position in the chain)
- Example:

SEQ	4	3	2	7	3	6

LEN(SEQ) = 6 // Length of SEQ

SEQ[0] = 4 SEQ[3] = 7
SEQ[1] = 3 SEQ[4] = 3
SEQ[2] = 2 SEQ[5] = 6

Hands on

- How would you implement Swap in an array in Pseudocode?

SWAP(SEQ, i, j)

- Example:

SEQ = [A, B, C, D, E]
SWAP(SEQ, 1, 4)
SEQ = [A, E, C, D, B]

SWAP

SWAP (SEQ, i, j)

1. SEQ[i] ← SEQ[j]

2. SEQ[j] ← SEQ[i]

END

Does this work?

Why / Why not?

SWAP

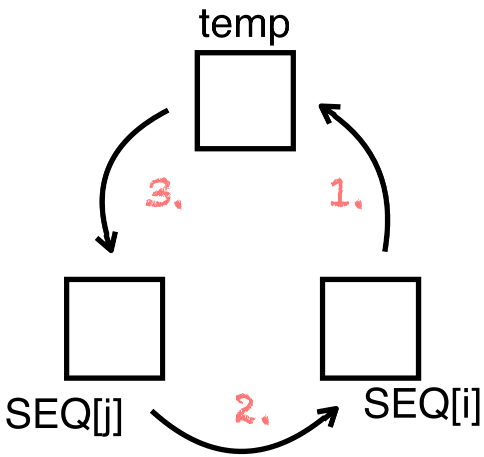
SWAP (SEQ, i, j)

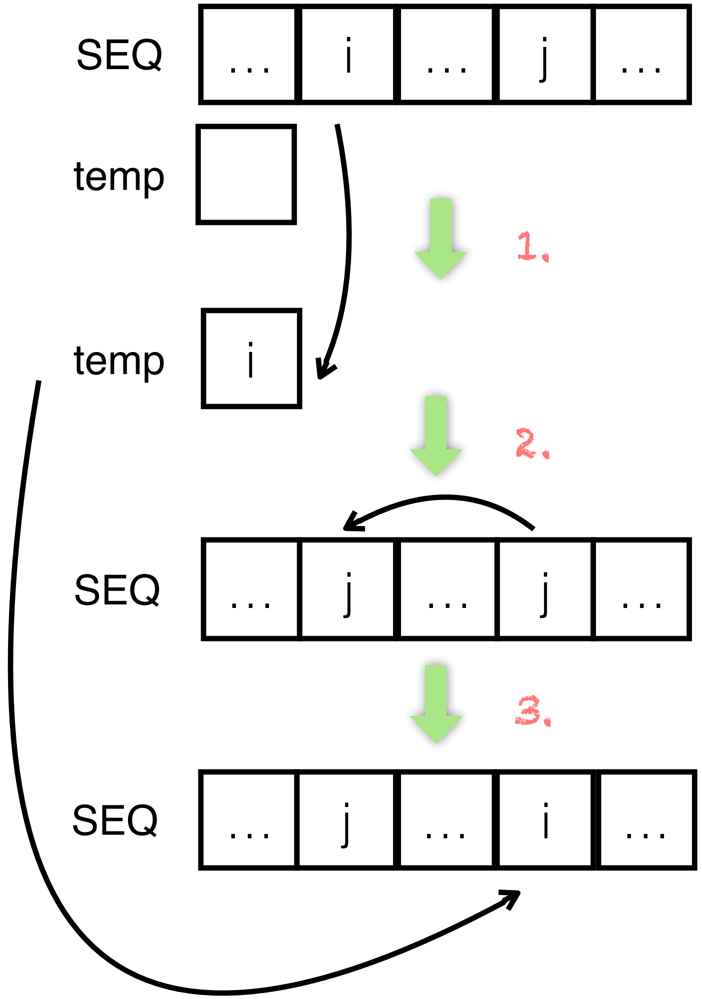
1. temp ← SEQ[i]

2. SEQ[i] ← SEQ[j]

3. SEQ[j] ← temp

END





Discussion

- SWAP(SEQ, i, j) == SWAP(SEQ, j, i) ?
- Symmetric in 2nd and 3rd input parameters
- What other kinds of operations/functions are symmetric?
  - ADD(i, j), MULTIPLY(i, j)

Hopefully, you will be like…

Kung Fu Panda (2008)
4min 12sec

https://www.youtube.com/watch?v=84VtdVK2a0A

One last thing for today

FIND_MAX

- Idea: Find largest value in an array of numbers

- Example:

SEQ

4	3	2	7	3	6

Largest value = 7
Largest index = 3

SEQ

-4	3	2	-7	3	-6

Largest value = 3
Largest index = 1 or 4?

FIND_MAX

- Should FIND_MAX return:
    - “largest value”, or
    - “index of largest value”?
- Why?

Homework

1) Find recipe of favourite food (as per the survey!)

Write algorithm so that a computer/automated chef can understand it.
(Use repetitions and function calls where suitable!)

2) Write pseudocode of FIND_MAX(SEQ),
which returns the <u>first index</u> of the largest value

FIND_MAX(SEQ)

1. …

END

If you are interested…

- Topics covered:
  - Pseudocode Structure
  - Working model of a computer
  - Arrays
  - Factorial, Swap, Find_max

Computational Thinking

Temasek Junior College

Davin Choo
cxjdavin+CTC@gmail.com

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Homework

Present your pseudocode for **MULTIPLY(A, B)**
using only additions

May assume that A and B are both *natural numbers*

Multiply

- Definition:
  - A*B = A + A + … + A (B times)
- Is there a pattern here?
  Can we break down the definition into smaller, easier parts?
  - A*1 = A ← Base case
  - A*B = A + (A * (B-1)) ← Recursive case

Multiply

MULTIPLY(A, B)

1. result ← 0
2. WHILE (B ≥ 1)
3. result ← result + A
4. B ← B - 1
5. END WHILE
6. RETURN result

END

Question:
What if I change to > ?
Will it work?

Which definition is this using?

Can we use the other one?

Recall:
A*B = A + A + … + A
A*B = A + (A * (B-1))

Multiply

```
MULTIPLY(A, B)
1.  IF (B == 1)
2.      RETURN A
3.  ELSE
4.      RETURN A + MULTIPLY(A, B-1)
5.  END IF
END
```

<u>Recall</u>:
A*B = A + A + … + A
A*B = A + (A * (B-1))

Continuing from last week…

Let’s finish off the material from last week,
and then we’ll start on **Javascript**!

(if time permits)

FIND_MAX

- Idea: Find largest value in an array of numbers
- Example:

SEQ

4	3	2	7	3	6

Largest value = 7
Largest index = 3

SEQ

-4	3	2	-7	3	-6

Largest value = 3
Largest index = 1 or 4?

Find Max

Question:

What if I change to ≤ ?

Will it work?

```
FIND_MAX(SEQ)
currentMax ← -∞;  maxIndex ← -1; i ← 0
WHILE (i < LEN(SEQ))
    IF (SEQ[i] > currentMax)
        currentMax ← SEQ[i]; maxIndex ← i
    END IF
    i ← i+1
END WHILE
RETURN maxIndex
END
```

Question:

What if I want the *last* index?

What if I want *all* indices?

SEQ	4	3	2	7	3	6

SEQ	-4	3	2	-7	3	-6

Computational Thinking

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cxjdavin+CTC@gmail.com

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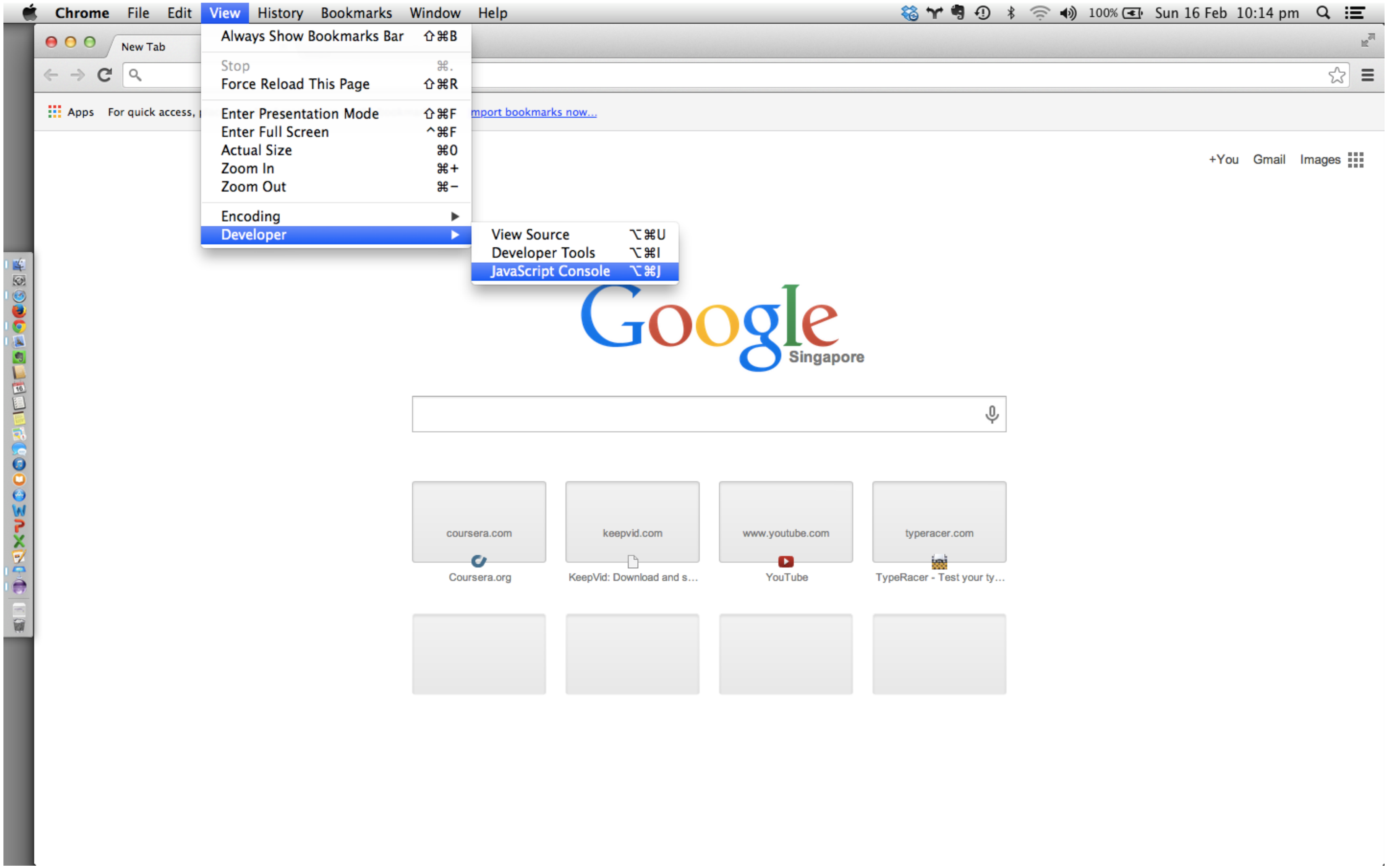
Why Javascript (JS)

- Every *modern* browser comes with a javascript compiler
- Supports multiple programming paradigms
- You can use it to make interesting web applications or make your websites more interesting (together with HTML and CSS)

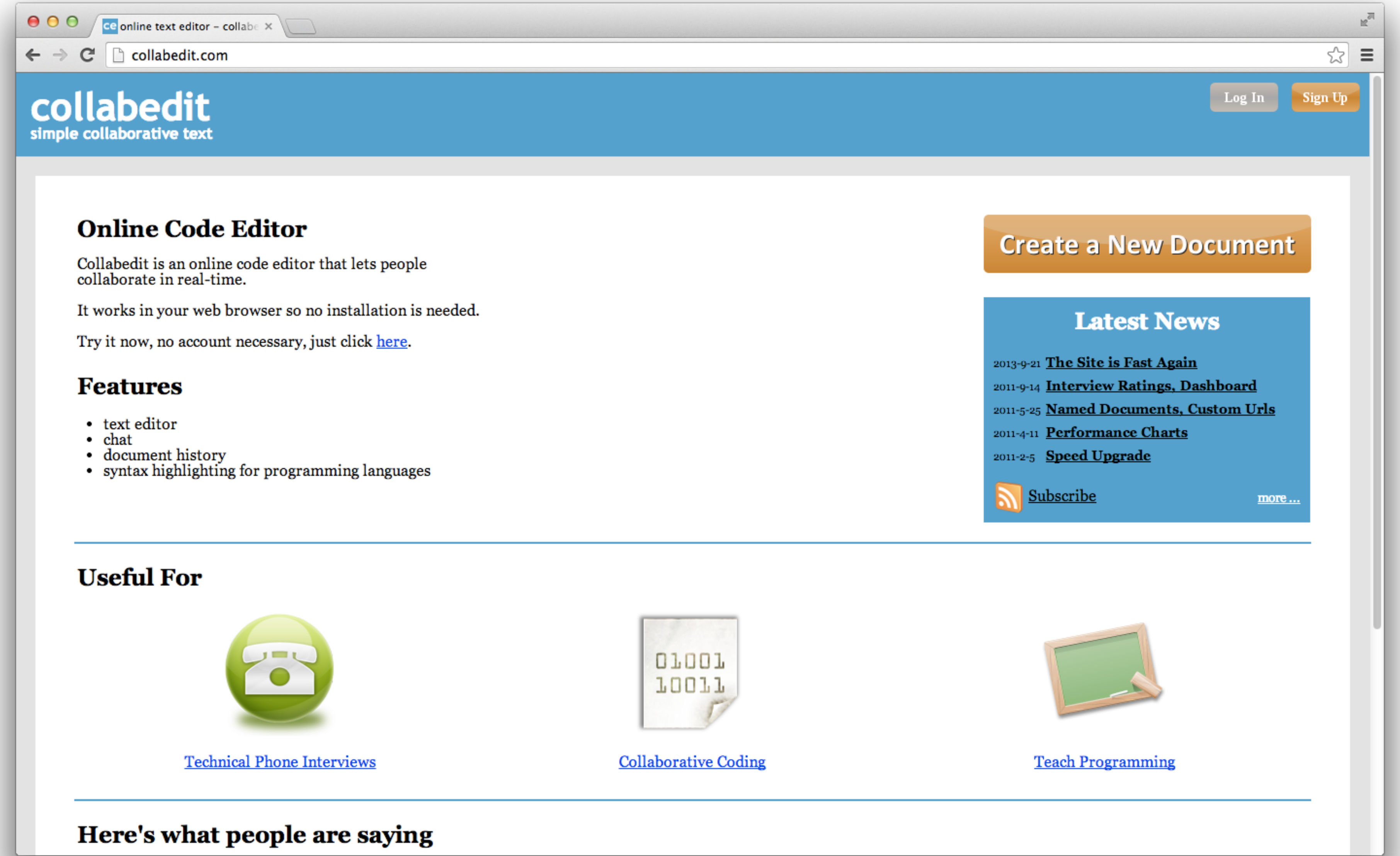
Working environments

- Chrome developer console
- Collabedit (http://collabedit.com)
- Notepad / Any text editors

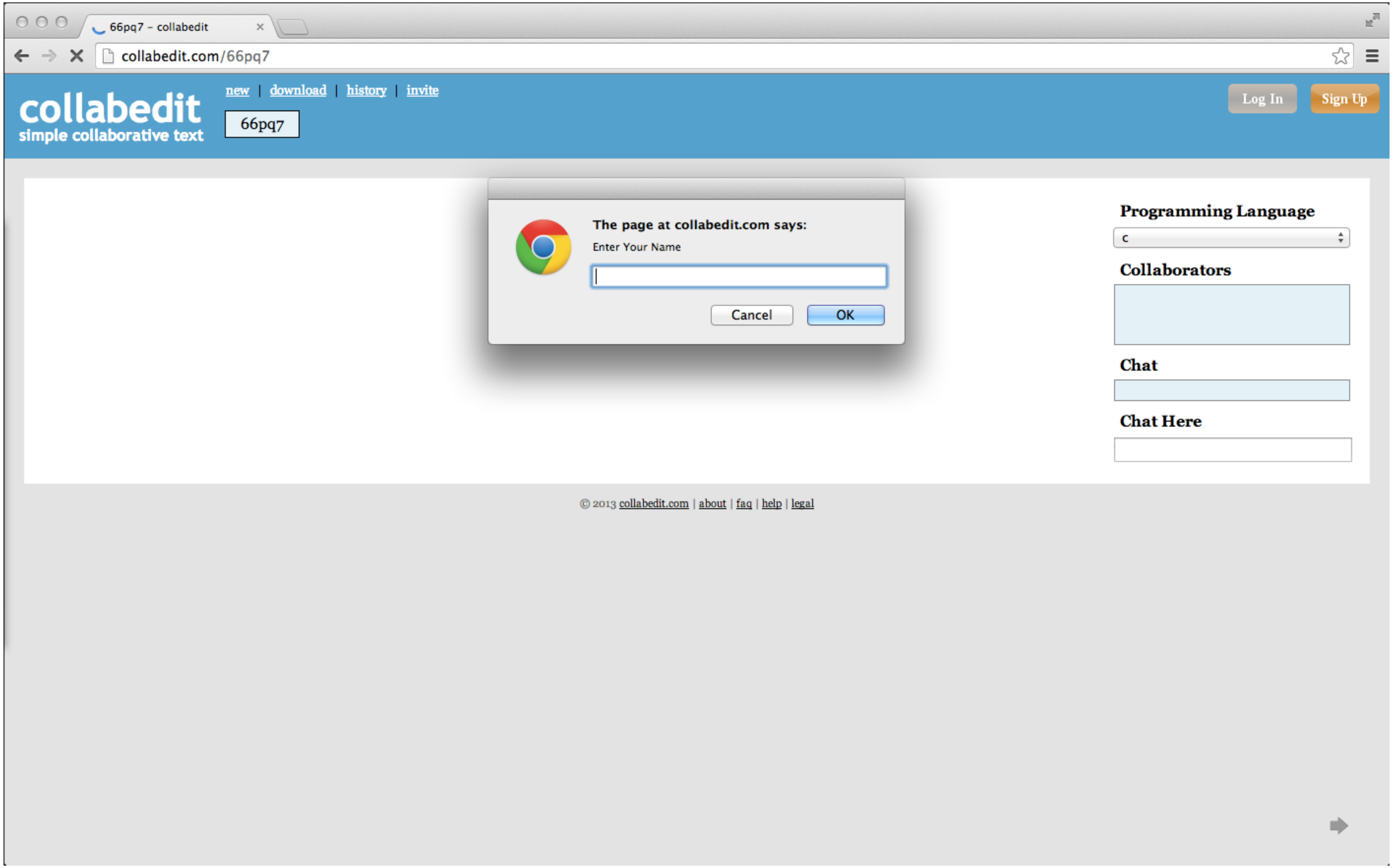
Chrome Developer Console



Collabedit


online text editor - collab
collabedit.com
collabedit
simple collaborative text
Log In
Sign Up
Online Code Editor
Collabedit is an online code editor that lets people collaborate in real-time.
It works in your web browser so no installation is needed.
Try it now, no account necessary, just click here.
Features
text editor
chat
document history
syntax highlighting for programming languages
Create a New Document
Latest News
2013-9-21 The Site is Fast Again
2011-9-14 Interview Ratings, Dashboard
2011-5-25 Named Documents, Custom Urls
2011-4-11 Performance Charts
2011-2-5 Speed Upgrade
Subscribe
more ...
Useful For
01001
10011
Technical Phone Interviews
Collaborative Coding
Teach Programming
Here's what people are saying

Collabedit


66pq7 – collabedit
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collabedit
simple collaborative text
new | download | history | invite
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Enter Your Name
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OK
Programming Language
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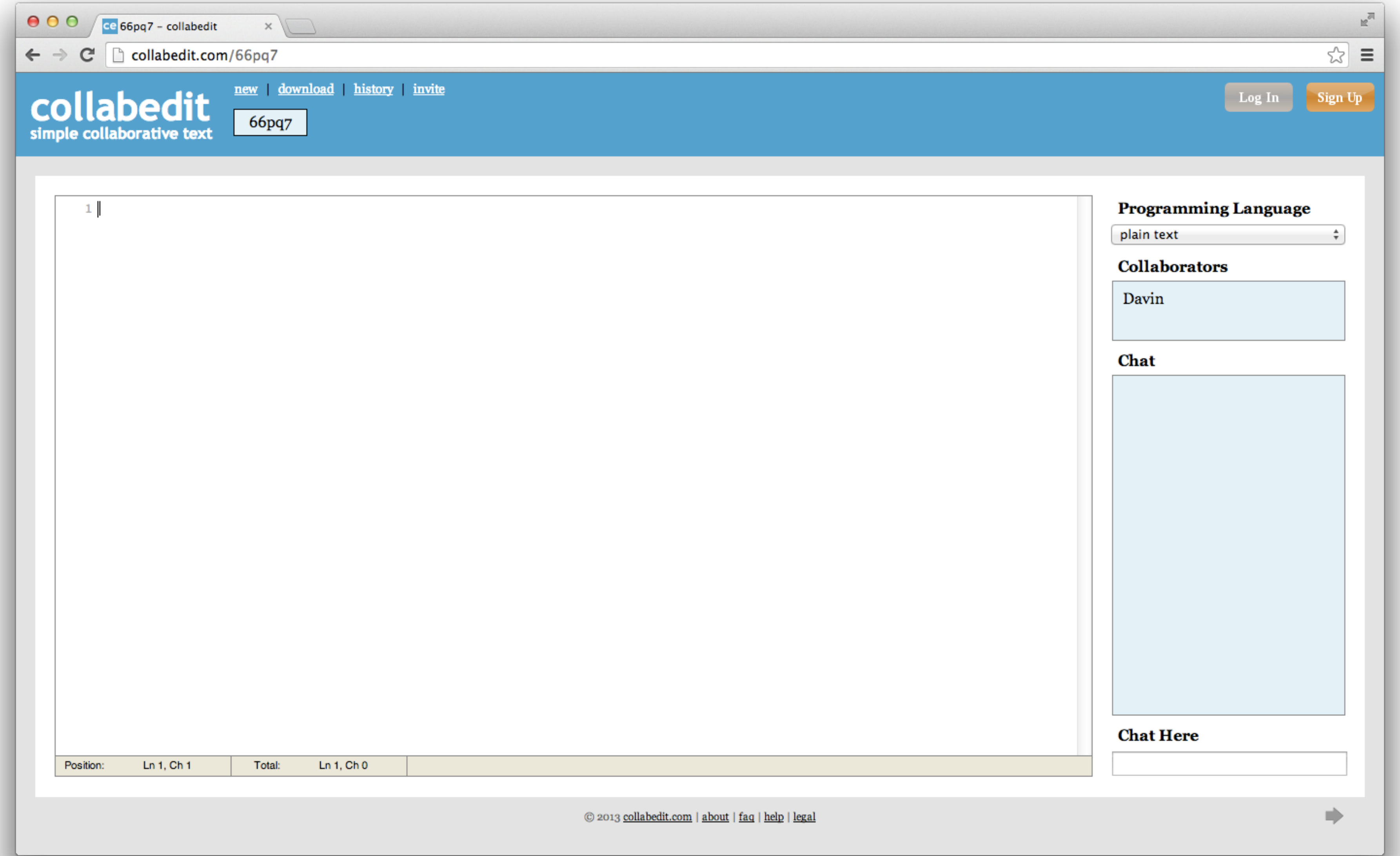
Collabedit


66pq7 – collabedit
collabedit.com/66pq7
collabedit
simple collaborative text
new | download | history | invite
66pq7
Log In
Sign Up
Programming Language
plain text
Collaborators
Davin
Chat
Chat Here
Position: Ln 1, Ch 1
Total: Ln 1, Ch 0
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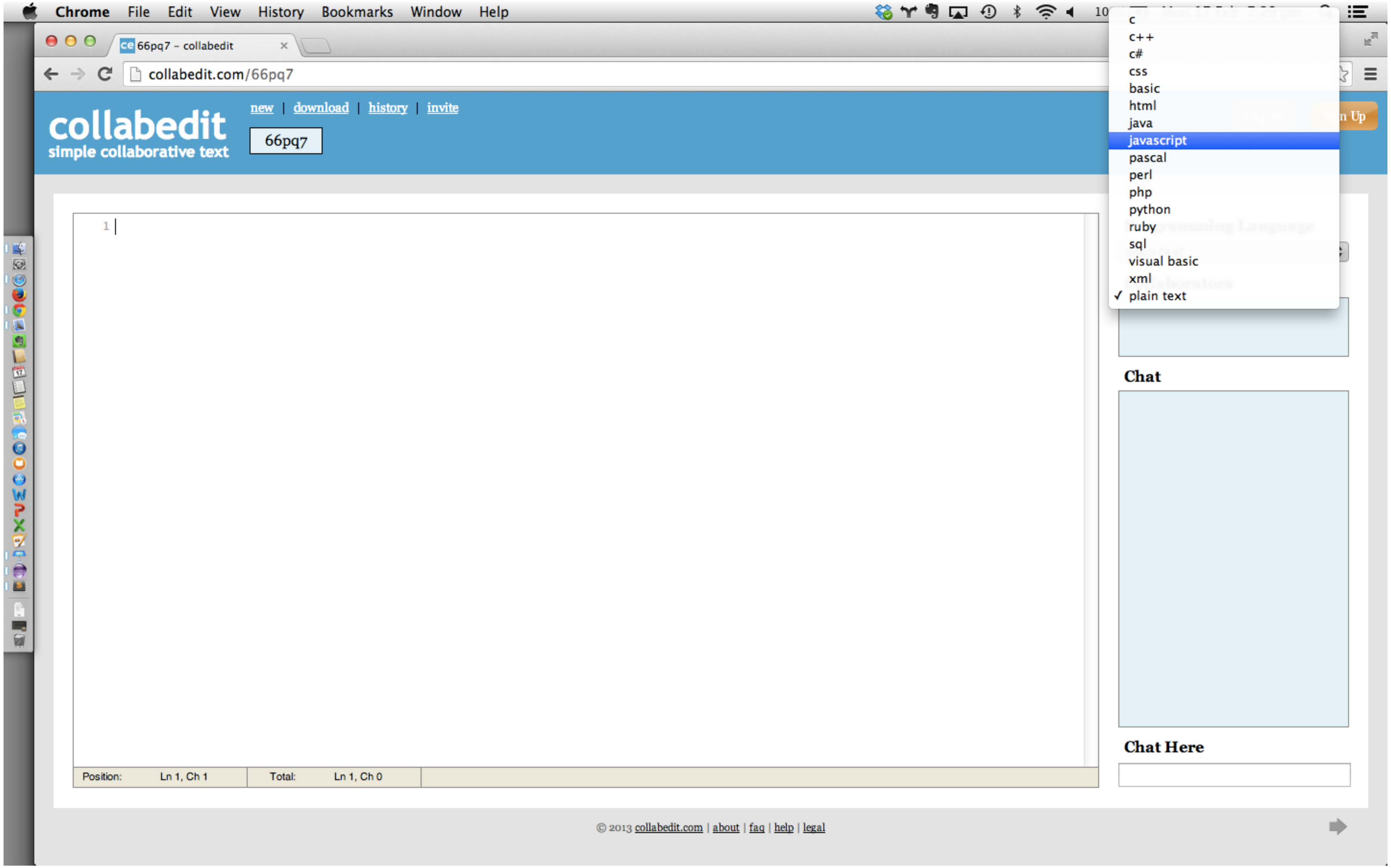
Collabedit



Chrome File Edit View History Bookmarks Window Help
66pq7 - collabedit
collabedit.com/66pq7
collabedit
simple collaborative text
new | download | history | invite
66pq7
c
c++
c#
css
basic
html
java
javascript
pascal
perl
php
python
ruby
sql
visual basic
xml
plain text
Chat
Chat Here
Position: Ln 1, Ch 1
Total: Ln 1, Ch 0
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Syntax vs. Semantics

- Syntax
    - “Grammar structure”
- Semantics
    - Meaning

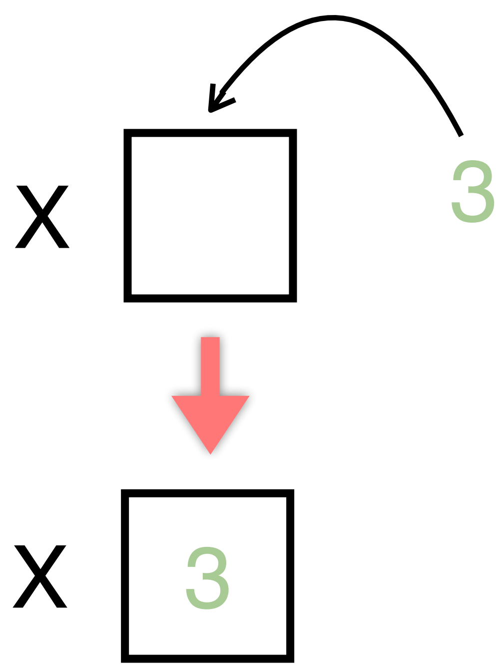
Syntax vs. Semantics

- John ate a hotdog
- Syntax
  - John [Noun], ate [verb], hotdog [Noun]
  - Sentence Form: <Noun> <Verb> <Noun>
- Semantics

http://www.culinate.com/articles/opinion/diet_for_children

Syntax vs. Semantics

- "Store the value 3 into the variable (box) X"
- Syntax
  - X ← 3 (Pseudocode)
  - var X = 3; (Javascript)
- Semantics



Basic Javascript Syntax

- Simple building blocks

    1. ~~Numbering~~
    2. Comments
    3. Assignment
    4. Print/Return
    5. Conditionals (if-else)
    6. Repetition (while-loops)
    7. Function calls

From
Pseudocode
slides

2. Comments
3. Assignments

```
> var X = 3; // Assigns the value 3 to the variable X
  undefined
> X
  3
>
```

4. Print/Return

Print

`> console.log(X)`	
`3`	Print
`<· undefined`	Returned
`> console.log(1+1)`	
`2`	Print
`<· undefined`	Returned
`>`	

5. Conditionals

```
IS_EVEN (N)

IF (N % 2 == 0)

        RETURN TRUE

ELSE

        RETURN FALSE

END IF

END
```

Pseudocode

```
> function isEven(N) {
      if (N % 2 == 0) {
          return true;
      } else {
          return false;
      }
  }
  undefined
> isEven(5)
  false
> isEven(4)
  true
> |
```

Returns nothing

Javascript

6. Repetition

```
SAY_HI_N_TIMES (N)
    WHILE (N != 0)
        PRINT “HI”
        N ← N - 1
    END WHILE
END
```

```
> function sayHiNTimes(N) {
      while (N != 0) {
          console.log("Hi");
          N = N-1; // We can also write N -= 1
      }
  }
  undefined
> sayHiNTimes(1)
  Hi
<· undefined
> sayHiNTimes(5)
5 Hi
<· undefined
> sayHiNTimes(-1)
65472 Hi
```

Returns nothing

Prints 5 times

Pseudocode

Javascript

Caused my Chrome to hang

7. Function Calls

```
MAKE_EVEN (N)
1.  IF (!IS_EVEN(N))
2.      RETURN PLUS_ONE(N)
3.  ELSE
4.      RETURN N
5.  END IF
END
```

Pseudocode

```
> function plus_one(N) {
      return N+1;
  }
  undefined
> function makeEven(N) {
      if (!isEven(N)) {
          return plus_one(N);
      } else {
          return N;
      }
  }
  undefined
> makeEven(1)
  2
> makeEven(4)
  4
> |
```

Javascript

MULTIPLY(A,B) in JS

```
MULTIPLY(A, B)

1.  result ← 0

2.  WHILE (B ≥ 1)

3.      result ← result + A

4.      B ← B - 1

5.  END WHILE

6.  RETURN result

END
```

Pseudocode

```javascript
function multiply(A, B) {
    var result = 0;
    while (B >= 1) {
        result = result + A;
        B = B - 1;
    }
    return result;
}
```

Javascript (Collabedit)

```
> function multiply(A, B) {
      var result = 0;
      while (B >= 1) {
          result = result + A;
          B = B - 1;
      }
      return result;
  }
  undefined
> multiply(2,3)
  6
> multiply(43,123)
  5289
>
```

Javascript (Chrome)

Testing…

MULTIPLY(A,B) in JS

```
MULTIPLY(A, B)

1.  IF (B == 1)

2.      RETURN A

3.  ELSE

4.      RETURN A + MULTIPLY(A, B-1)

5.  END IF

END
```

Pseudocode

```javascript
function multiply(A, B) {
    if (B == 1) {
        return A;
    } else {
        return A + multiply(A, B-1);
    }
}
```

Javascript
(Collabedit)

```
> function multiply(A, B) {
      if (B == 1) {
          return A;
      } else {
          return A + multiply(A, B-1);
      }
  }
  undefined
> multiply(3,2)
  6
> multiply(123,43)
  5289
>
```

Javascript
(Chrome)

Testing…

Sequences/Arrays in JS

SEQ	4	3	2	7	3	6

```
LEN(SEQ) = 6        // Length of SEQ
  SEQ[0] = 4          SEQ[3] = 7
  SEQ[1] = 3          SEQ[4] = 3
  SEQ[2] = 2          SEQ[5] = 6
```

Pseudocode

```
> var SEQ = [4, 3, 2, 7, 3, 6]
  undefined
> SEQ[0]
  4
> SEQ[1]
  3
> SEQ[2]
  2
> SEQ[3]
  7
> SEQ[4]
  3
> SEQ[5]
  6
> SEQ[6]
  undefined
> SEQ[-1]
  undefined
>
```

"Out of bounds"

Javascript

Homework

Write Javascript code for:
FACTORIAL(N) and **SWAP(SEQ, i, j)**

- Both versions of Factorial, so 3 codes in total
- Make sure it works
  - Try on some simple test cases
  - Check output by hand
- Email me your code in ".txt" format by **Sunday 23rd Feb 2014**

If you are interested…

- Topics covered:
  - Syntax vs. Semantics
  - Basic Javascript syntax

Computational Thinking

Temasek Junior College

Davin Choo
cxjdavin+CTC@gmail.com

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Plans for today

- Recap some basic Javascript
- Practice, practice, practice!
- Learn Binary Search
- Update on interesting problem set:
    - Currently still in talks to with Professor Martin Henz and his team on getting hold of it

Homework

Write Javascript code for:
FACTORIAL(N) and **SWAP(SEQ, i, j)**

- <u>Both</u> versions of Factorial, so 3 codes in total
- Make sure it works
  - Try on some simple test cases
  - Check output by hand

Questions asked

- How to type Javascript
  - Chrome console vs. Collabedit vs. Notepad
  - Syntax (Review in a bit)
- How to test

Method 1 (Collabedit)

1. Type in **Collabedit**
2. Copy the entire function
3. Open Chrome console
4. Paste into Chrome console

Method 2 (Notepad)

1. Type in **Notepad**
2. Copy the entire function
3. Open Chrome console
4. Paste into Chrome console

Method 3 (Console)

1. Open Chrome console

2. Type in Chrome console

3. Use Shift+Enter to go to the next line of your code

Things to remember

- Use “1 tab” or “4 spaces” to indent your code
    - Improve readability
- Curly braces “{“ and “}”
- “var”
- Capitalisation makes a difference
- Don’t type the numberings in JS!
    - That’s for line referencing purposes

Basic Javascript Syntax

- Simple building blocks

    1. ~~Numbering~~
    2. Comments
    3. Assignment
    4. Print/Return
    5. Conditionals (if-else)
    6. Repetition (while-loops)
    7. Function calls

From
Pseudocode
slides

2. Comments
3. Assignments

```
> var X = 3; // Assigns the value 3 to the variable X
  undefined
> X
  3
>
```

4. Print/Return

Print

```
> console.log(X)
  3
<· undefined
> console.log(1+1)
  2
<· undefined
> |
```

Print

Returned

Print

Returned

5. Conditionals

```
IS_EVEN (N)

IF (N % 2 == 0)

        RETURN TRUE

ELSE

        RETURN FALSE

END IF

END
```

Pseudocode

```
> function isEven(N) {
      if (N % 2 == 0) {
          return true;
      } else {
          return false;
      }
  }
  undefined
> isEven(5)
  false
> isEven(4)
  true
> |
```

Returns nothing

Javascript

6. Repetition

```
SAY_HI_N_TIMES (N)

1.    WHILE (N != 0)

2.        PRINT "HI"

3.        N ← N - 1

4.    END WHILE

END
```

Pseudocode

```
> function sayHiNTimes(N) {
      while (N != 0) {
          console.log("Hi");
          N = N-1; // We can also write N -= 1
      }
  }
  undefined
> sayHiNTimes(1)
  Hi
<· undefined
> sayHiNTimes(5)
5 Hi
<· undefined
> sayHiNTimes(-1)
65472 Hi
```

Returns nothing

Prints 5 times

Javascript

Caused my Chrome to hang

7. Function Calls

```
MAKE_EVEN (N)
    IF (!IS_EVEN(N))
        RETURN PLUS_ONE(N)
    ELSE
        RETURN N
    END IF
END
```

Pseudocode

```
> function plus_one(N) {
      return N+1;
  }
  undefined
> function makeEven(N) {
      if (!isEven(N)) {
          return plus_one(N);
      } else {
          return N;
      }
  }
  undefined
> makeEven(1)
  2
> makeEven(4)
  4
> |
```

Javascript

Hands on

- Pair up and code up:
  - Factorial
    (Iterative version)
  - Factorial
    (Recursive version)
  - Swap (Given SEQ, i, j)

- Pairs
  - **Wee Teck**, *Taha*
  - **Leng Ze**, *Natalie*
  - **Nicolas**, *Yun Fen*

Those who did, guide *those who didn't*.
<u>Don't</u> just type for them

How to test

- Suppose you coded up function **fun()**
- Create “test cases”
  - Pick <{inputs}, output>. Check output by hand.
- Run **fun(inputs)** in console
- Does it return output?
  - If yes, it passed this test case. But not necessarily correct.
  - If not, it is definitely wrong.

Example

- factorial(3) = 6
  - <{inputs}, output> = <{3}, 6>
- swap([1, 2, 3], 0, 1) returns [2, 1, 3]
  - <{inputs}, output> = <{[1, 2, 3], 0, 1}, [2, 1, 3]>

Binary Search

- Recall what is an array/sequence
- Assume it is sorted in some fixed order
  - “Ascending”, based on some measure
- <u>Question</u>:
  Is “x” in the array?
  If yes, give me its index
  If no, tell me it is not in the array.

Binary Search

- Examples
  - Searching in a dictionary
  - Searching in a telephone book
  - Searching in a list of names in a class roster
  - Etc…

Hands on

- <u>Question</u>:
  Is “x” in the array?
  If yes, give me its index
  If no, tell me it is not in the array.

- Find the following words in the dictionary:

  1. Pseudocode

  2. Algorithm

  3. Binary

Ideas?

1. Flip from front to end
    - Very slow. Worst case: Need to check all entries
2. Flip to some kind of pre-partitioned index and search within that section
    - Need to pre-process before hand
    - Still bad if partitions are huge
3. Binary search

Binary Search (Idea)

- If array is only length 1, check directly if x is there
- Otherwise:
  - Look at middle of array, is x there?
  - If yes, done
  - If no, ask whether x should be in left or right half?
  - Consider searching in that half

Hands on

Formulate the pseudocode of
Binary Search

Binary Search

```
BINARY_SEARCH (arr, L, R, x)
IF (L > R)
    RETURN -1                                      // Typical index value to denote failure
END IF
middle ← ⌈(L + R) / 2⌉                            // Calculate the middle page (round up)
IF (arr[middle] == x)                              // Suppose every page has only 1 name
    RETURN middle                                  // Return page number
ELSE IF (arr[middle] > x)                          // If middle page is “too large”
    RETURN BINARY_SEARCH (arr, L, middle-1, x)     // Recurse on left half
ELSE                                               // If middle page is “too small”
    RETURN BINARY_SEARCH (arr, middle+1, R, x)     // Recurse on right half
END IF
END
```

Homework

Write Javascript code for:
BINARY_SEARCH (arr, L, R, x)

- 1 code in total
- Make sure it works
  - *Start early!*
  - Specify and show at least 3 test cases
- Email me your code in “.txt” format by **<u>Sunday 2nd Mar 2014</u>**

If you are interested…

- Topics covered:
  - Revision of “Basic Javascript syntax”
  - Basic “test case” testing technique
  - Binary Search

Computational Thinking

Temasek Junior College

Davin Choo
cxjdavin+CTC@gmail.com

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Mini-test next Wed

12^{th} March

- 45 minutes, at the start, before we begin on Runes
    - Takes only ~10 minutes if you know your stuff
- Review what you have learnt so far
    - How to read & write Pseudocode
    - How to read & write Javascript code / Translate from Pseudocode
    - Recursion vs. Iteration

Plans for today

- Binary search. <u>Everyone</u> practice.
- Recursive solutions
- Iterative solutions

Binary Search (Idea)

- If array is only length 1, check directly if x is there
- Otherwise:
  - Look at middle of array, is x there?
  - If yes, done
  - If no, ask whether x should be in left or right half?
  - Consider searching in that half

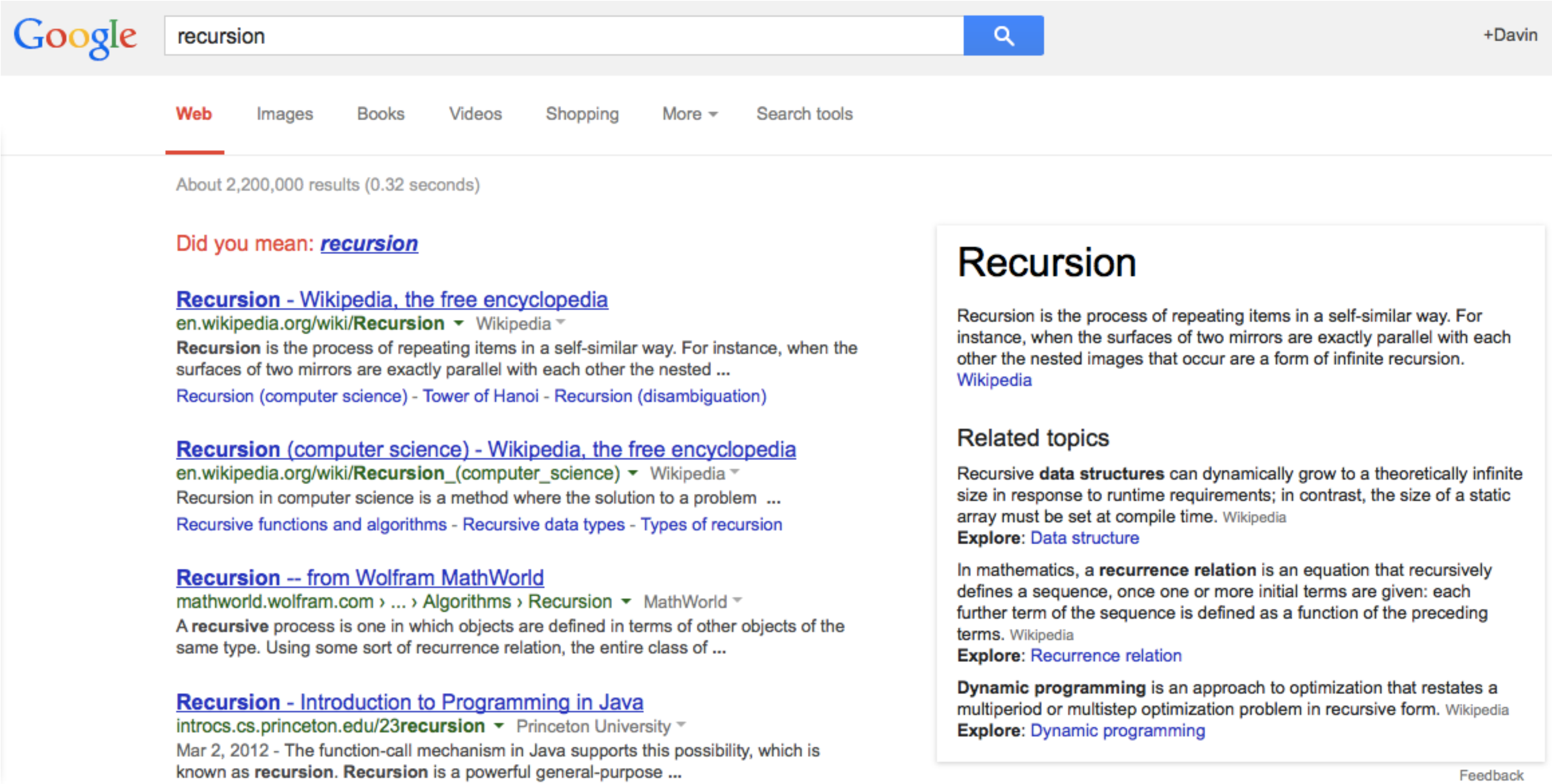
Binary Search

```
BINARY_SEARCH (arr, L, R, x)
IF (L > R)
    RETURN -1                                       // Typical index value to denote failure
END IF
middle ← ⌈(L + R) / 2⌉                              // Calculate the middle page (round up)
IF (arr[middle] == x)                               // Suppose every page has only 1 name
    RETURN middle                                   // Return page number
ELSE IF (arr[middle] > x)                           // If middle page is “too large”
    RETURN BINARY_SEARCH (arr, L, middle-1, x)      // Recurse on left half
ELSE                                                // If middle page is “too small”
    RETURN BINARY_SEARCH (arr, middle+1, R, x)      // Recurse on right half
END IF
END
```

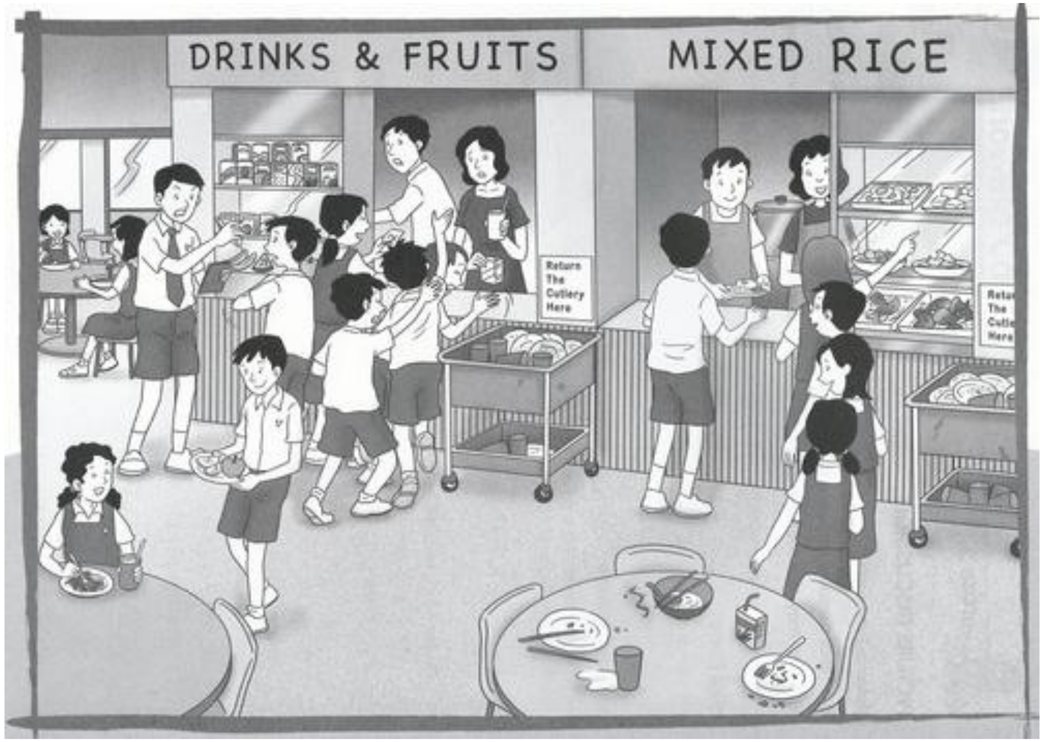
Recursive solutions

- Idea: Solve smaller parts, combine to form solution
- Components
    - Base case (BC)
    - Recursive case (RC)
- Identify the BC and RC in the following examples

Recursion Examples



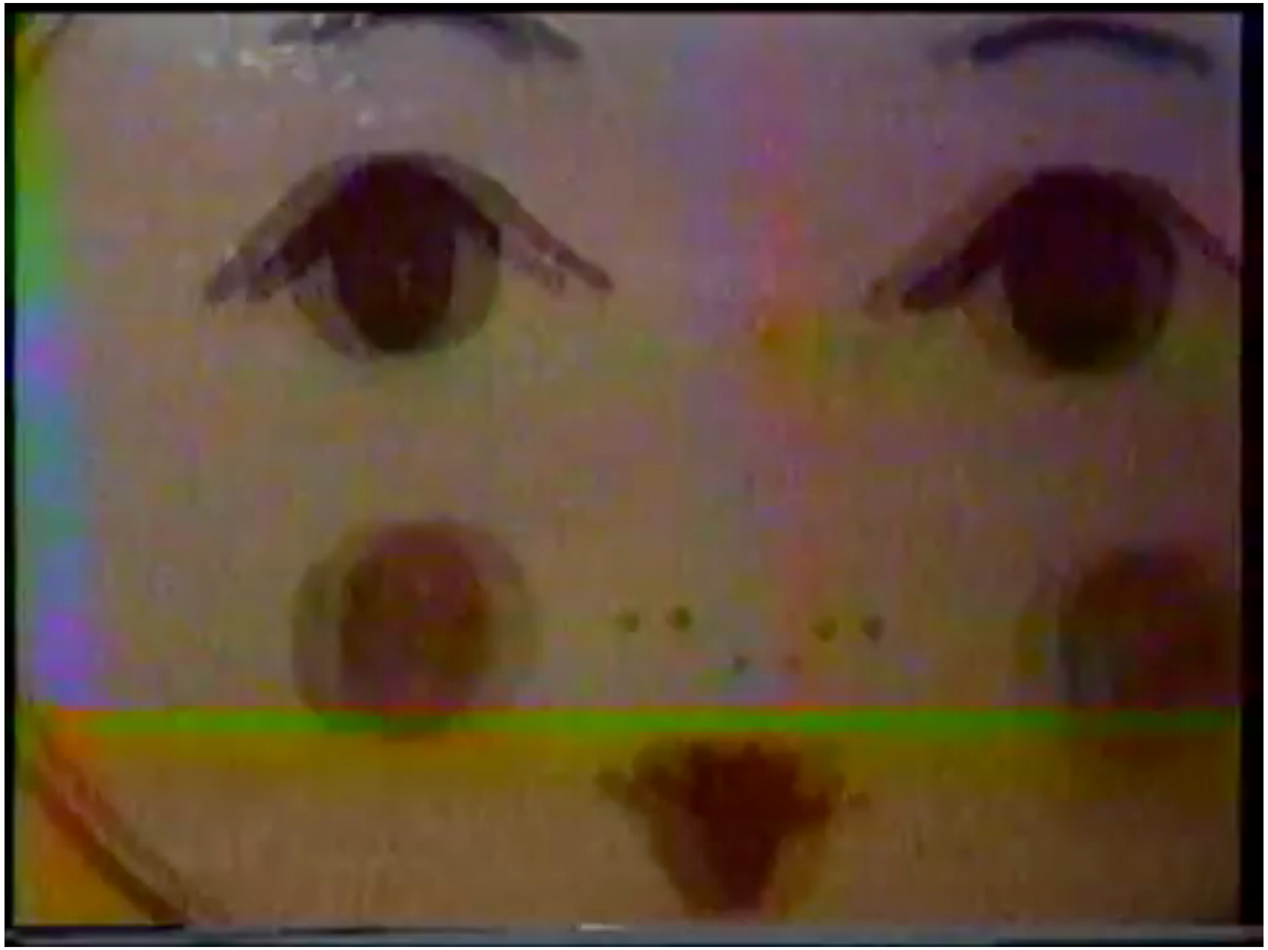
Recursion Examples



Canteen queue

http://linoit.com/entry/image/2182225

Recursion Examples



Sesame Street - Russian Dolls (1-10)

Russian Dolls

https://www.youtube.com/watch?v=aNQV45Wichw
http://upload.wikimedia.org/wikipedia/commons/7/7f/Floral_matryoshka_set_1.JPG

Recursion Examples

```
MULTIPLY(A, B)

1.  IF (B == 1)

2.      RETURN A

3.  ELSE

4.      RETURN A + MULTIPLY(A, B-1)

5.  END IF

END
```

Pseudocode for Multiply(A,B)

Recursion Examples

```
BINARY_SEARCH (arr, L, R, x)
IF (L > R)
    RETURN -1                                   // Typical index value to denote failure
END IF
middle ← ⌈(L + R) / 2⌉                          // Calculate the middle page (round up)
IF (arr[middle] == x)                           // Suppose every page has only 1 name
    RETURN middle                               // Return page number
ELSE IF (arr[middle] > x)                       // If middle page is "too large"
    RETURN BINARY_SEARCH (arr, L, middle-1, x)  // Recurse on left half
ELSE                                            // If middle page is "too small"
    RETURN BINARY_SEARCH (arr, middle+1, R, x)  // Recurse on right half
END IF
END
```

Iterative solutions

- Idea: Repeat step by step until termination
- Components
  - Iterating variable(s)
  - Terminating condition
- Identify the components in the following examples

Iteration Examples

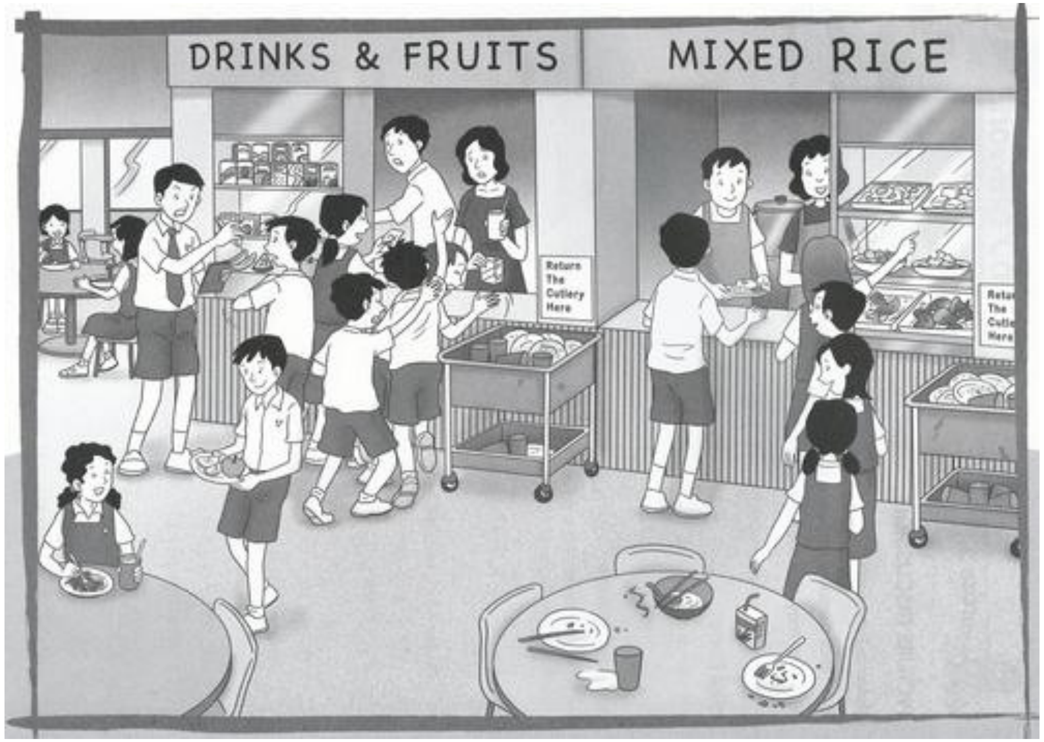
Doing a worksheet of N problems

Iteration Examples

```
MULTIPLY(A, B)
1.  result ← 0
2.  WHILE (B ≥ 1)
3.      result ← result + A
4.      B ← B - 1
5.  END WHILE
6.  RETURN result
END
```

Pseudocode for Multiply(A,B)

Iteration Examples



Canteen queue of N people

http://linoit.com/entry/image/2182225

Recursion vs. Iteration

- Recursion is performed iteratively in a computer
  - This means:
    Anything written in recursion form can be re-written in an equivalent iteration form
- Recursion form may be more intuitive, natural and/or easier to understand than it’s iterative form

Hands on

- Do it together on screen
- Both recursive and iterative solutions
- Remember testing

Hands on

- **addOne(x)**
- **addition(A,B)** using addOne(x). *result = A + B*
- **subtractOne(x)** using addOne(x). *result = A + B*
- **subtract(A,B)** using subtractOne(x). *result = A - B*
- **multiply(A,B)** using addition(A,B). *result = A * B*
- Challenge: **divide(A,B,n)**. *result = A/B*
  (where n is number of digits of answer)

Power

- Also called exponentiation
- power(A,B) = A^B
- E.g.
  - power(2,5) = 32
  - power(10,3) = 1000

Power

- power(A,B) = A^B
  - A*A*…*A (B times)
  - A * power(A, B-1)
- Which is recursive, which is iterative? What are the components?

Homework

Write Javascript code for: **POWER (A, B)**

- Both versions of power, so 2 codes in total
- Make sure it works
    - *Start early!*
    - Specify and show at least 3 test cases
- Email me your code in ".txt" format by **Sunday 9th Mar 2014**

Computational Thinking

Temasek Junior College

Davin Choo

cxjdavin+CTC@gmail.com

Mini-test
12th March

45 minutes, at the start, before we begin on Runes

Takes only ~10 minutes if you know your stuff

Runes Problem Set

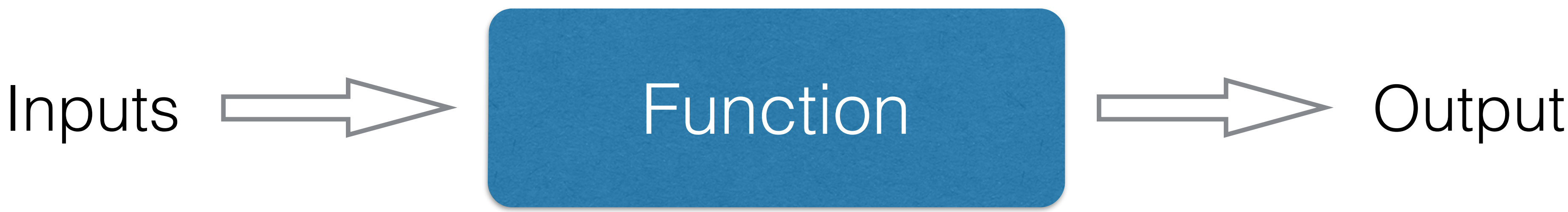
- Adapted from NUS Course:
  CS1101S Programming Methodology
  - First semester CS course that selected few go through
- Javascript implementation of Runes
  (Credit: Professor Martin Henz and his team)
- Modified slides from CS1101S
  (Credit: Professor Ben Leong)
- Quite a fair bit of things to cover.
  Please be more responsive and active in hands on.

Function

- A.k.a. “Procedure”
- Computers follow instructions <u>exactly</u>
- Associates a name to a sequence of operations
- e.g.
    - function addOne(x) { return x+1; }
    - function ASDF(x) { return x+1; }
    - These 2 functions are given different names but perform the exact same operations

Functional Abstraction

- Treat functions as “black box”
- You *only need to know* **<u>what</u>** it does
- You *don’t have to know* **<u>how</u>** it does it



Abstract Environment

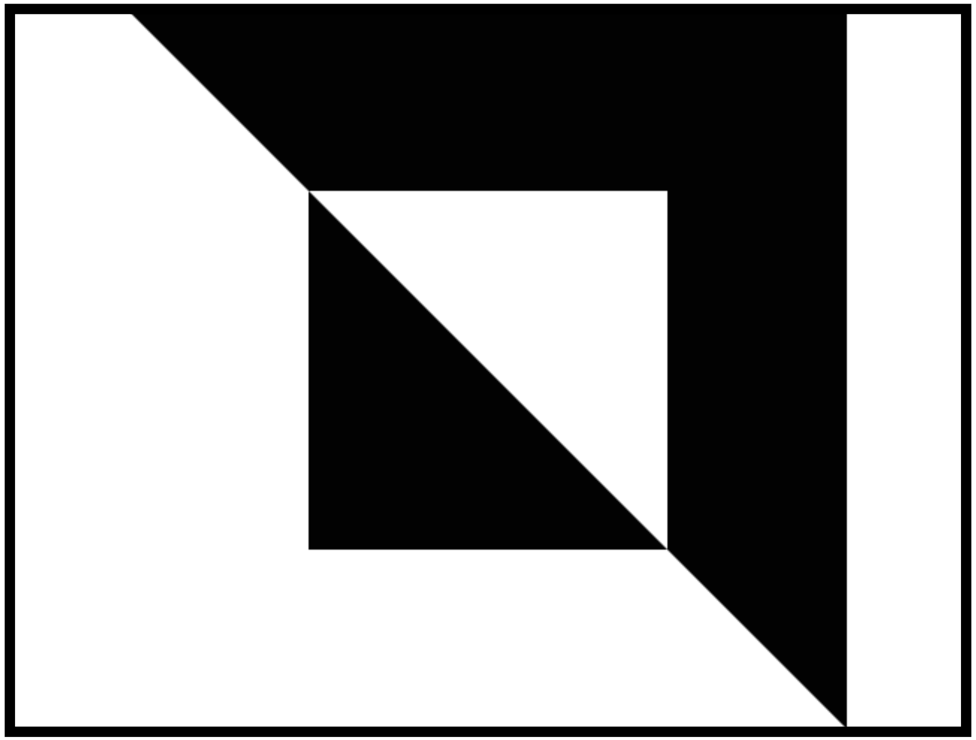
- Previous weeks:
    - Numbers
    - Mathematical functions
- Next few sessions:
    - Pictures! (“Runes”)

Elements of Programming

- Primitives
- Combination
- Abstraction

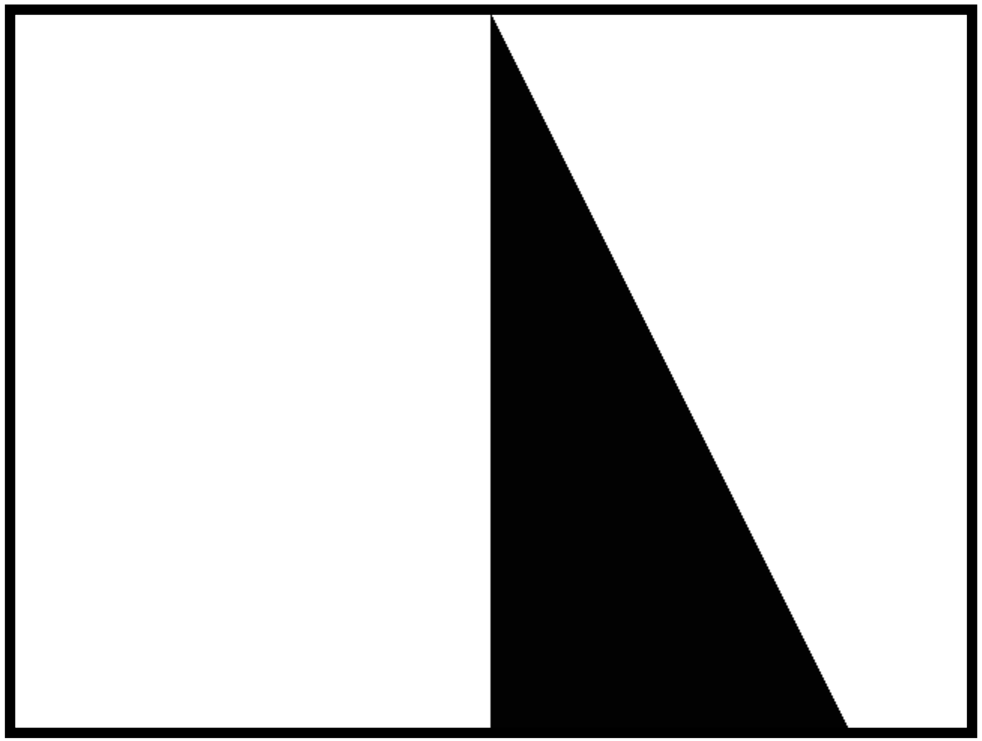
Primitives

show(rcross_bb)



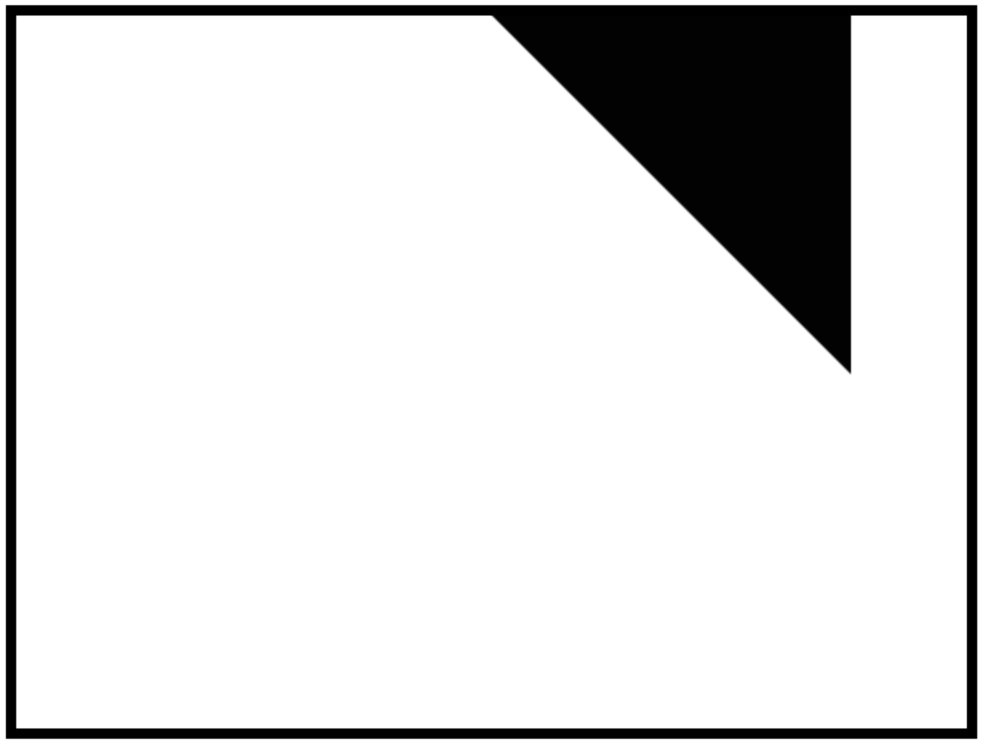
Primitives

show(sail_bb)



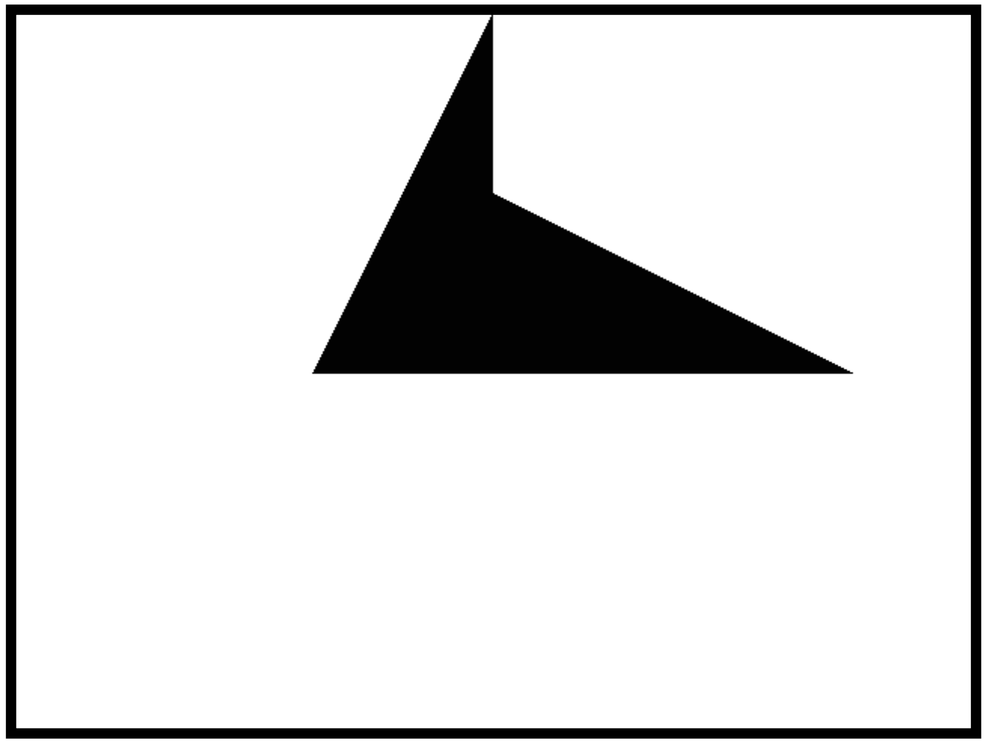
Primitives

show(corner_bb)



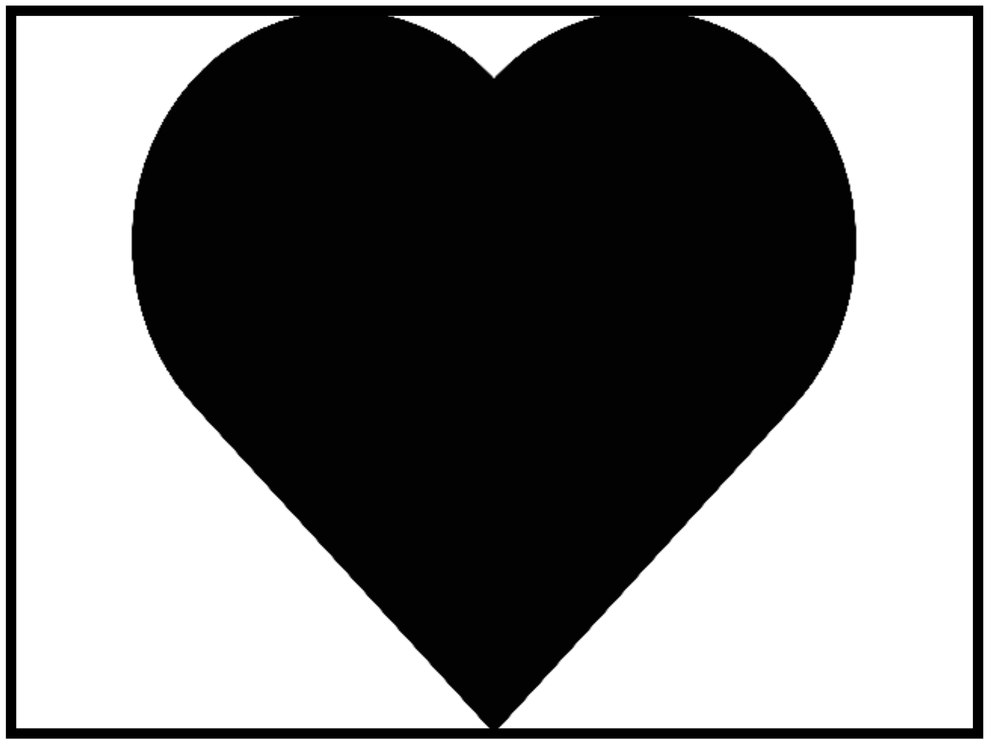
Primitives

show(nova_bb)



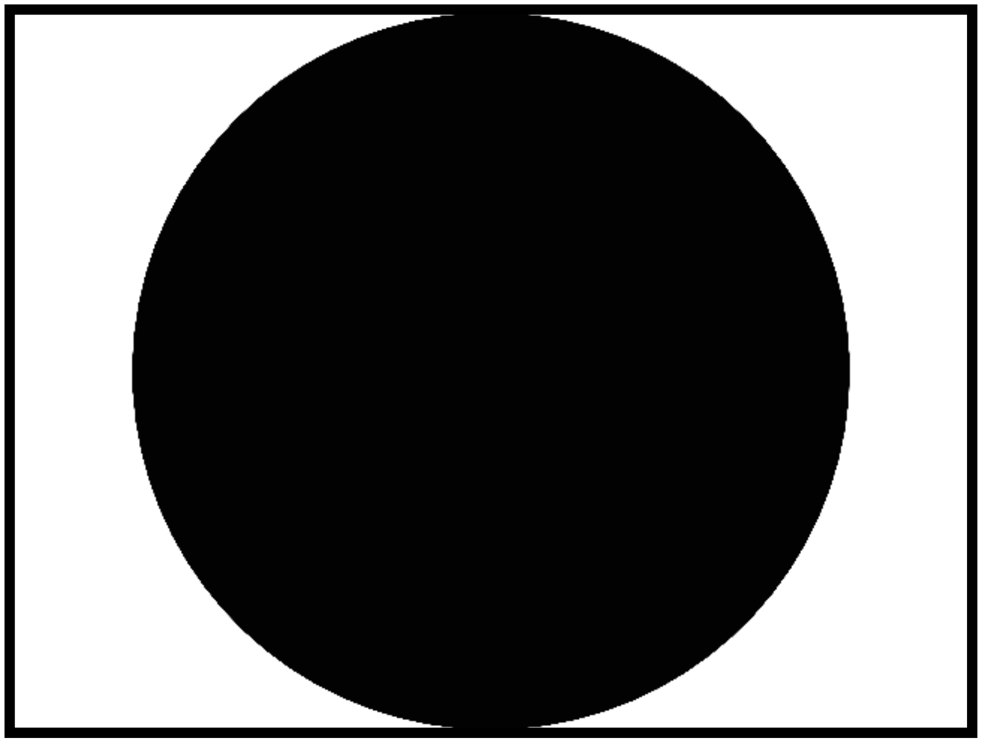
Primitives

show(heart_bb)



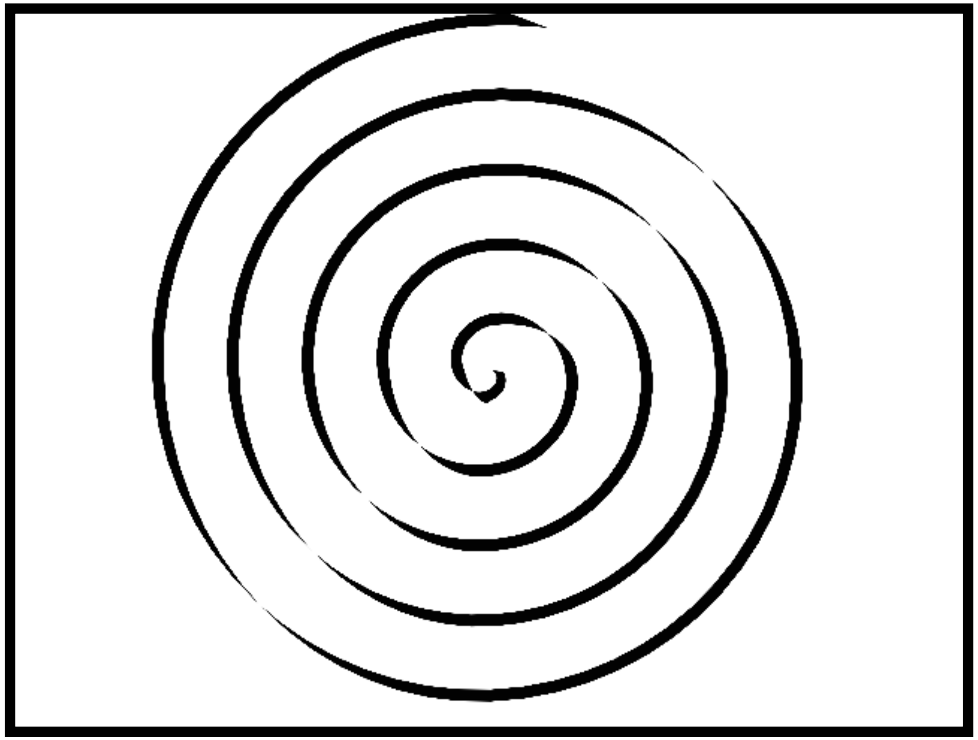
Primitives

show(circle_bb)



Primitives

show(ribbon_bb)



Primitives

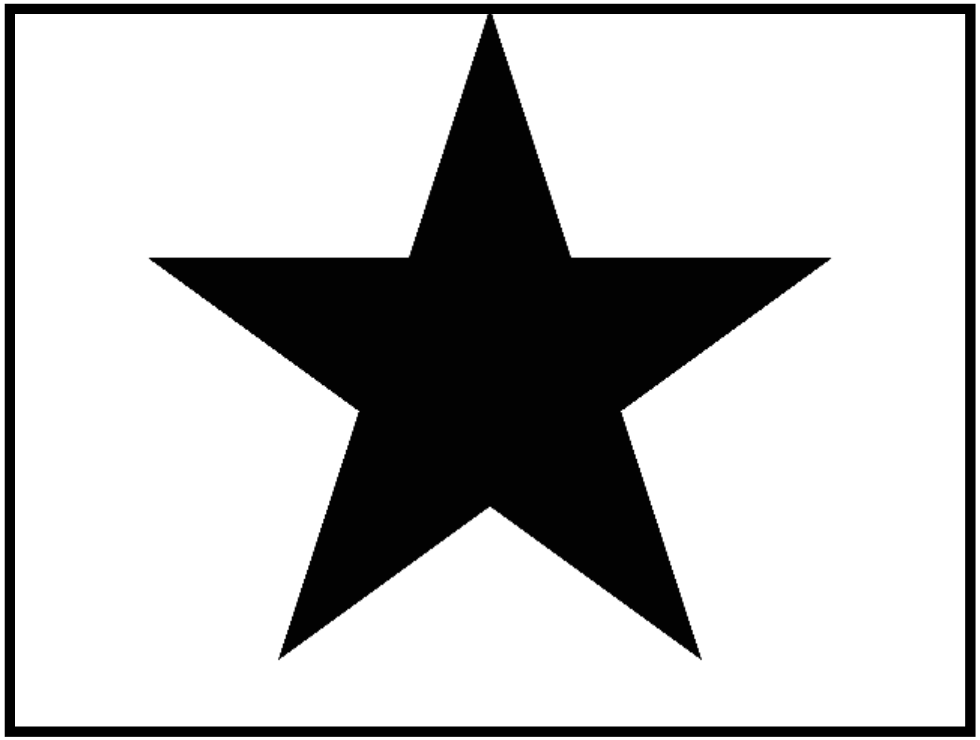
show(black_bb)

Primitives

show(blank_bb)

Primitives

show(pentagram_bb)



Wait…

- What does **show** do?
  - Take in an <u>image</u> and display it on Firefox
- How is **show** implemented?
  - We don’t care. We don’t need to know
  - “Functional abstraction”

How to get “clear” the box?

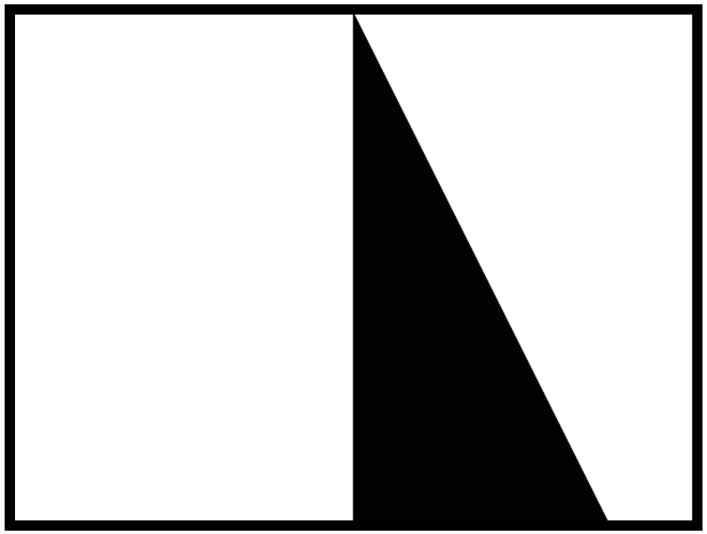
clear_all()

Rotating 90° clockwise

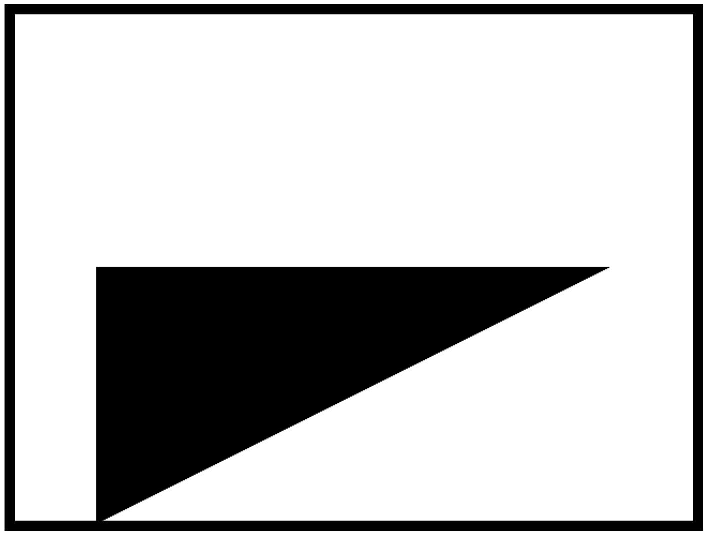
Operation Rune

show(quarter_turn_right(sail_bb))

Image → quarter_turn_right → Image (Rotated 90° clockwise)



Original

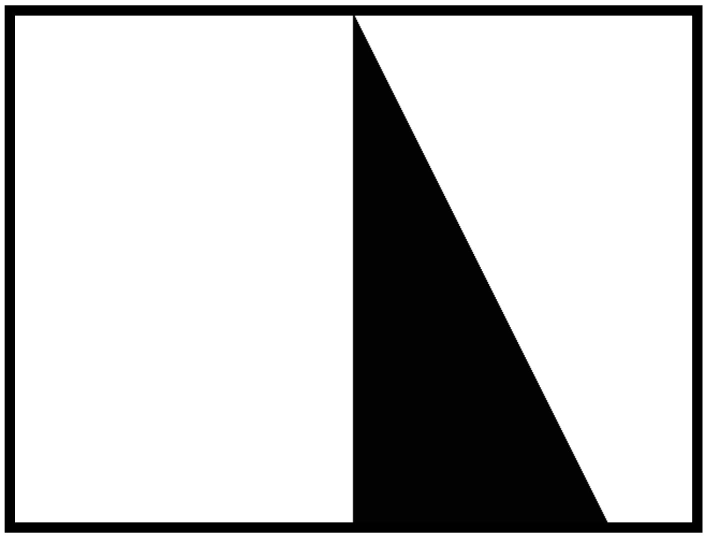


Result

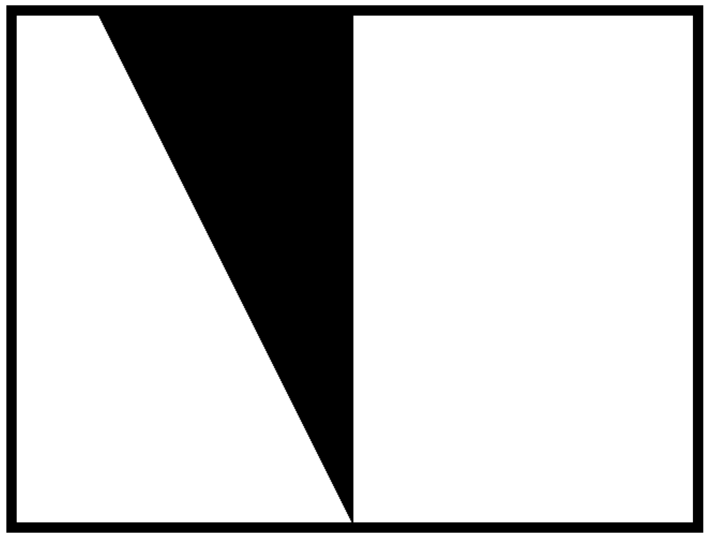
Rotating 180°?

```
function rotate180(img) {
    return quarter_turn_right(quarter_turn_right(img));
}

show(rotate180(sail_bb));
```



Original



Result

Rotating 90° left?

- Do we need a new primitive function?
- What can we make use of?

Image ⇒ **quarter_turn_right** ⇒ Image (Rotated 90° clockwise)

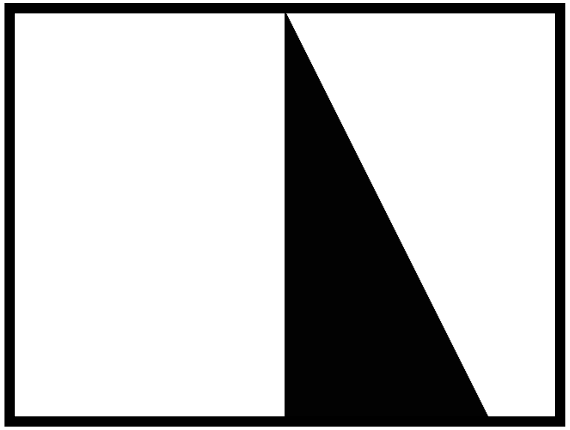
```
function quarter_turn_left(img) {
    return ____________________;
}
```

Combining using stack

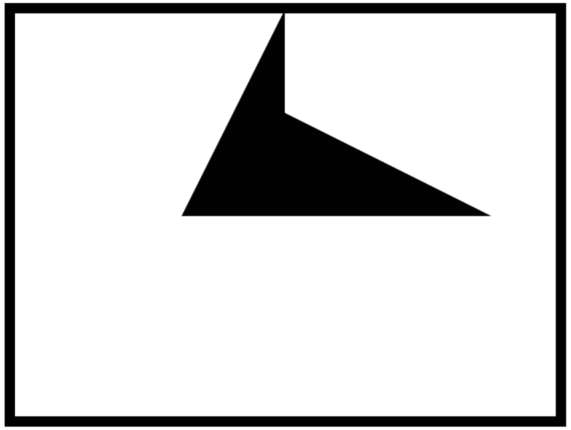
Op Rune 1 Rune 2

show(stack(sail_bb, nova_bb))

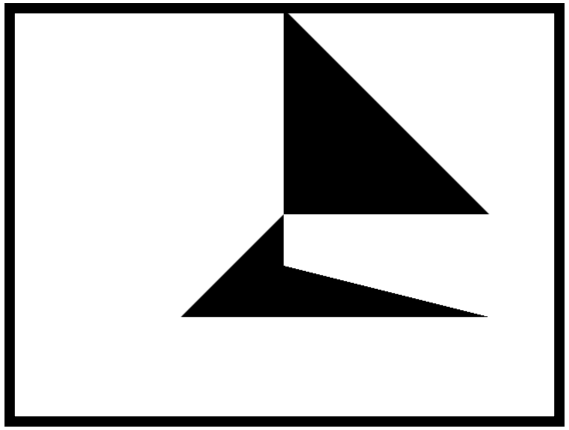
2 Images → stack → Image (Pic 1 on top of Pic 2)



sail_bb



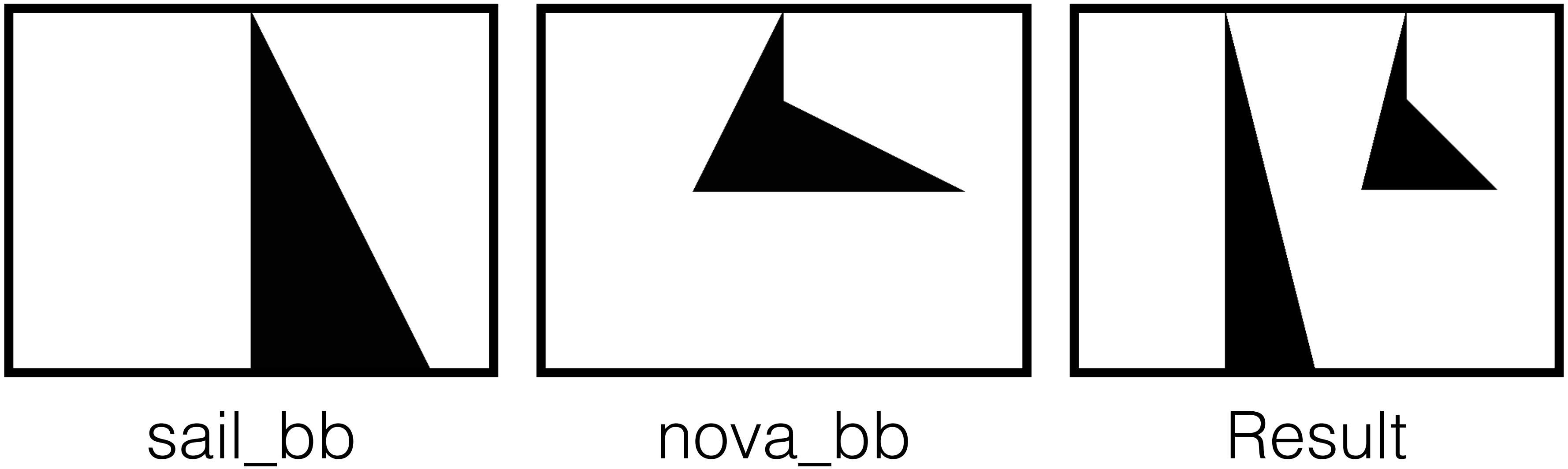
nova_bb



Result

Hands on

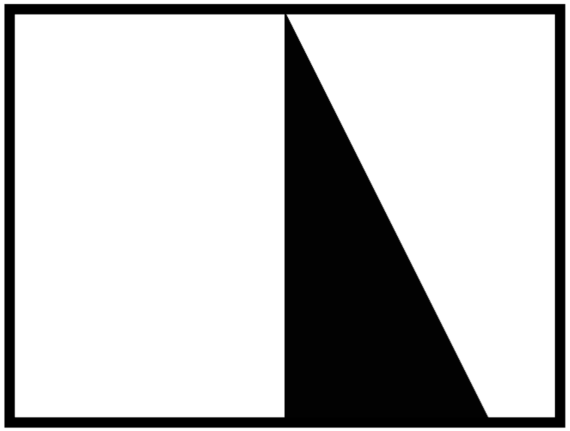
How do we do this?
(Put one rune beside another)



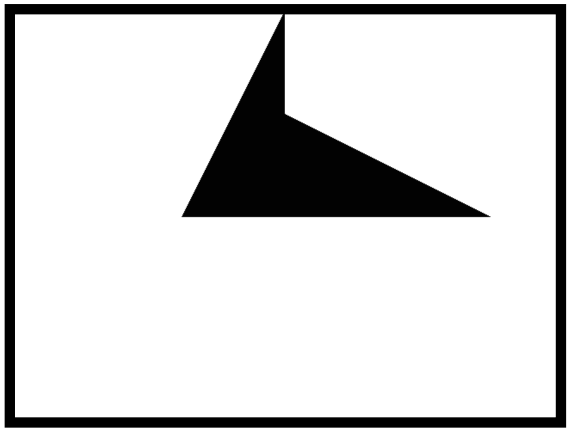
Use quarter_turn_left, quarter_turn_right, stack!

Beside

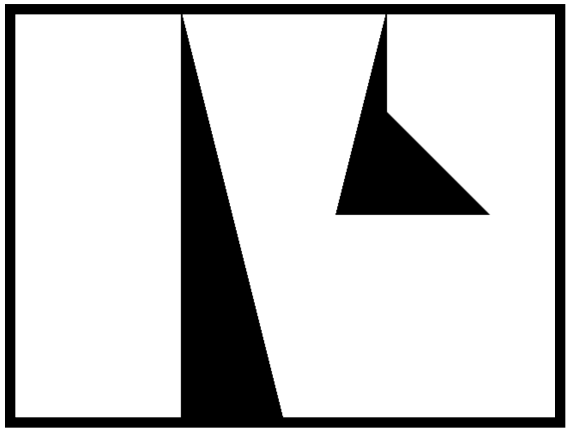
```
function beside(pic1, pic2) {
    return quarter_turn_left(stack(quarter_turn_right(pic1),
                                   quarter_turn_right(pic2)));
}
show(beside(pic1, pic2));
```



sail_bb

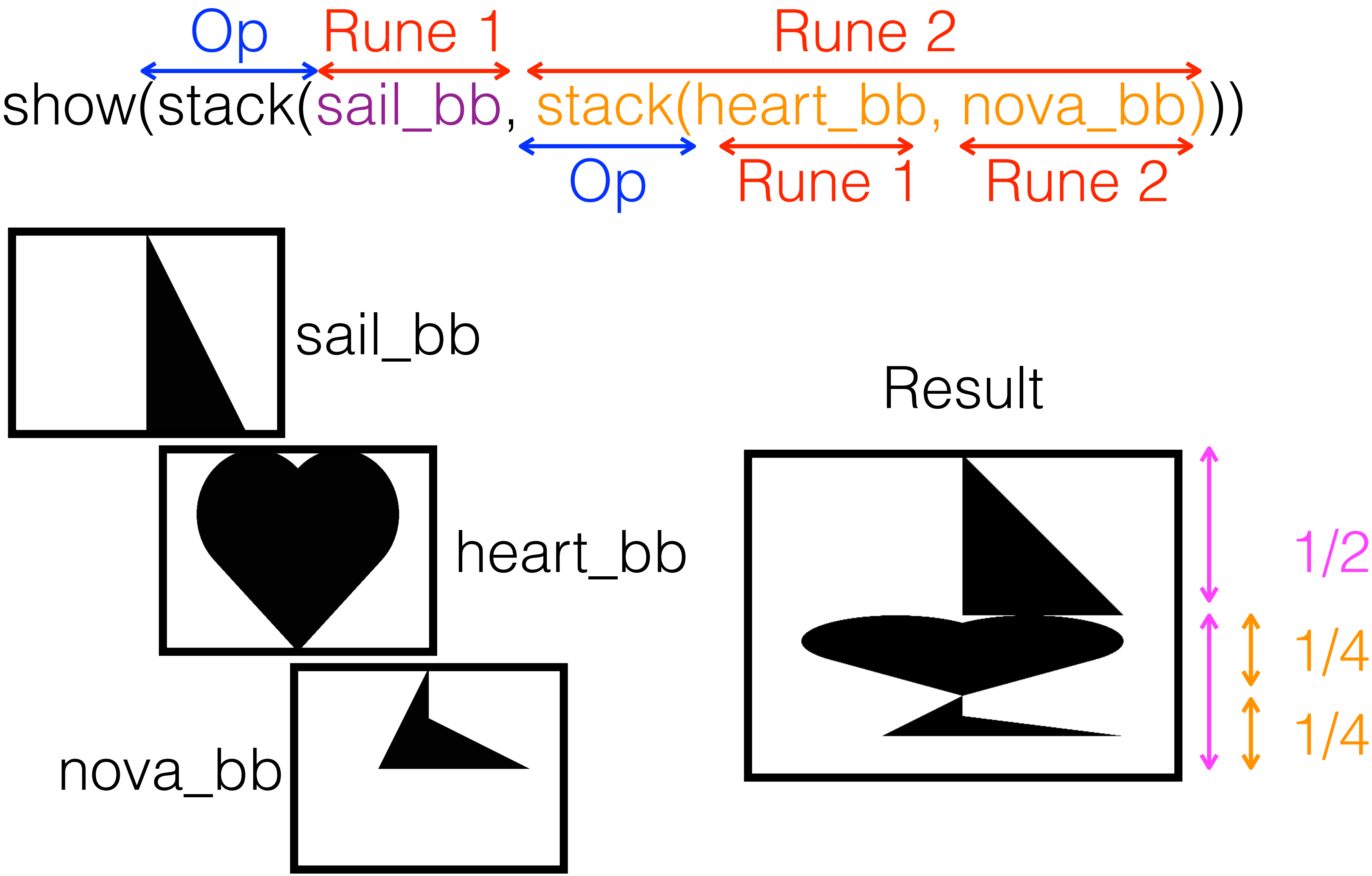


nova_bb



Result

Multiple Stacking



Multiple Beside

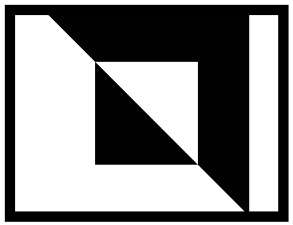
Same as multiple stack!

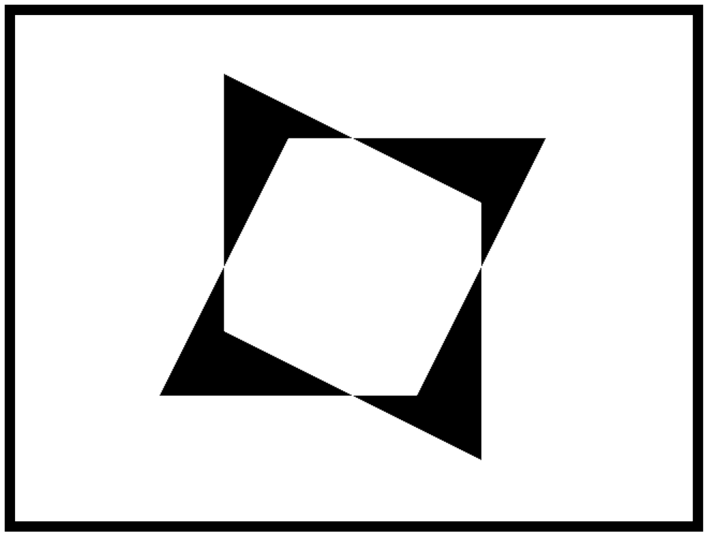
New Pattern

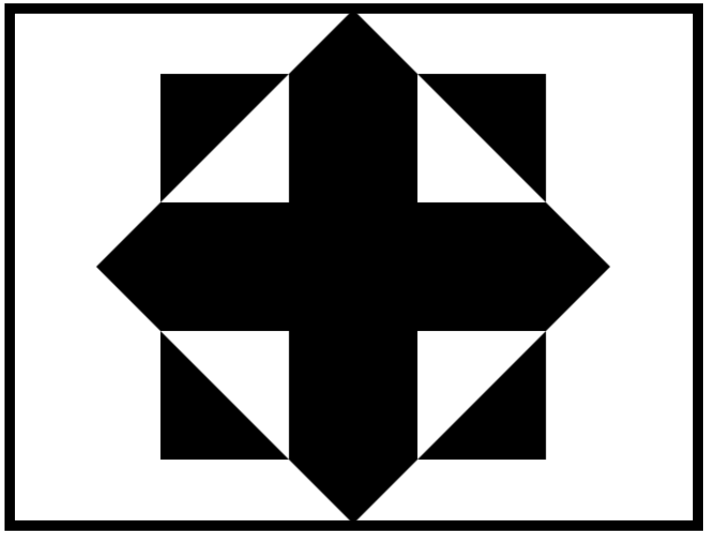
```
function make_cross(pic) {
    return stack(beside(quarter_turn_right(pic),
                        rotate180(pic)),
                 beside(pic,
                        quarter_turn_left(pic)));
}
```

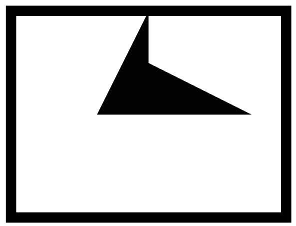
New Pattern

show(make_cross(rcross_bb))





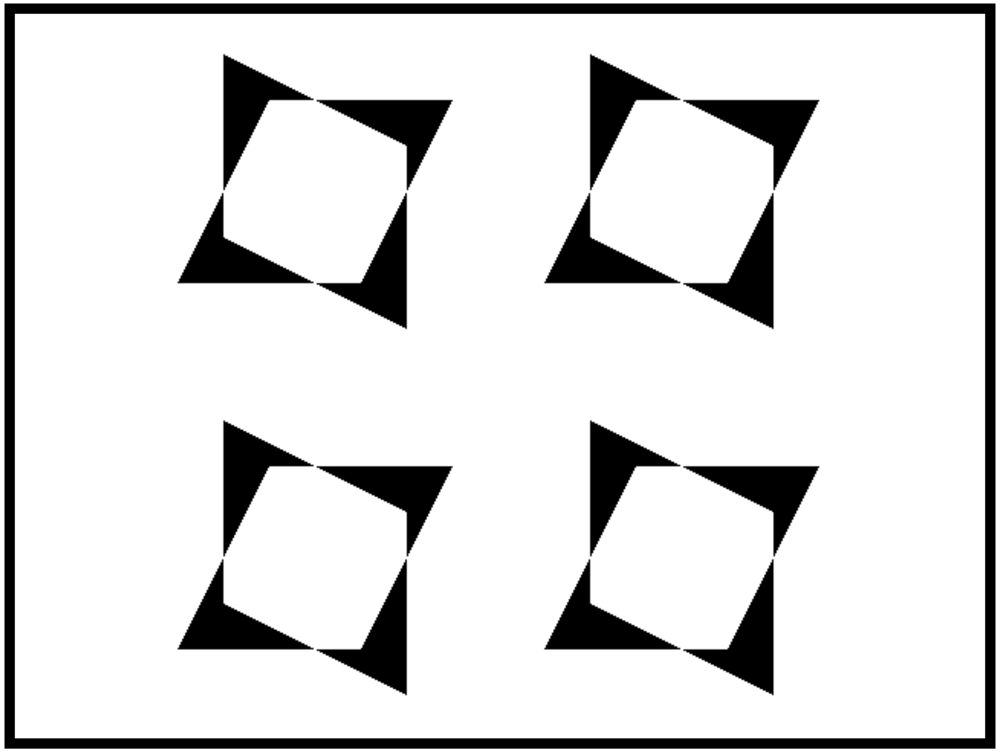




show(make_cross(nova_bb))

Repeating Patterns

show(make_cross(make_cross(nova_bb))



OR

var myPic = make_cross(nova_bb)
show(make_cross(myPic))

Repeating Patterns

What if we want <u>more than</u> just repeating *once*?

Recursion / Iteration!

Hands on

- repeat_pattern(n, pat, rune)
  - n = Number of times to apply pattern
  - pat = pattern to repeat
  - rune = image to apply pattern on

Repeating Patterns

Recursive solution

```
function repeat_pattern(n, pat, rune) {
    if (n == 0) {
        return rune;
    } else {
        return pat(repeat_pattern(n-1, pat, rune));
    }
}
```

Repeating Patterns

<u>Iterative solution</u>

```
function repeat_pattern(n, pat, pic) {
    var result = pic;
    while (n > 0) {
        result = pat(result);
        n = n-1;
    }
    return result;
}
```

Recall…

Op Rune 1 Rune 2

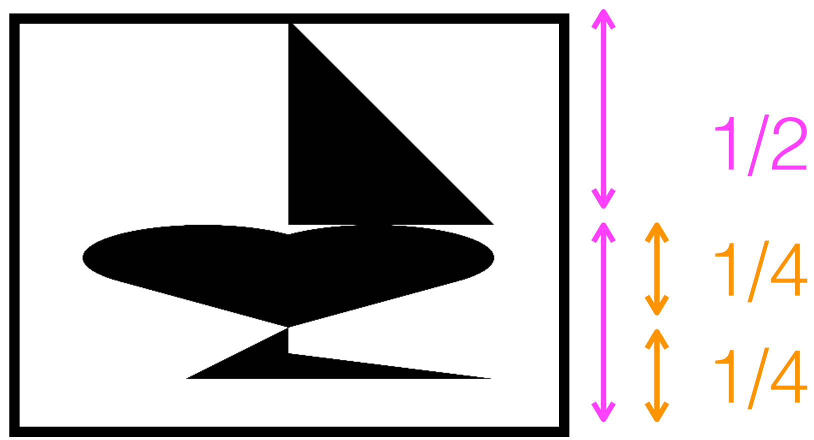
show(stack(sail_bb, stack(heart_bb, nova_bb)))

Op Rune 1 Rune 2

We want equal splitting for all rows!

New primitive:
stack_frac

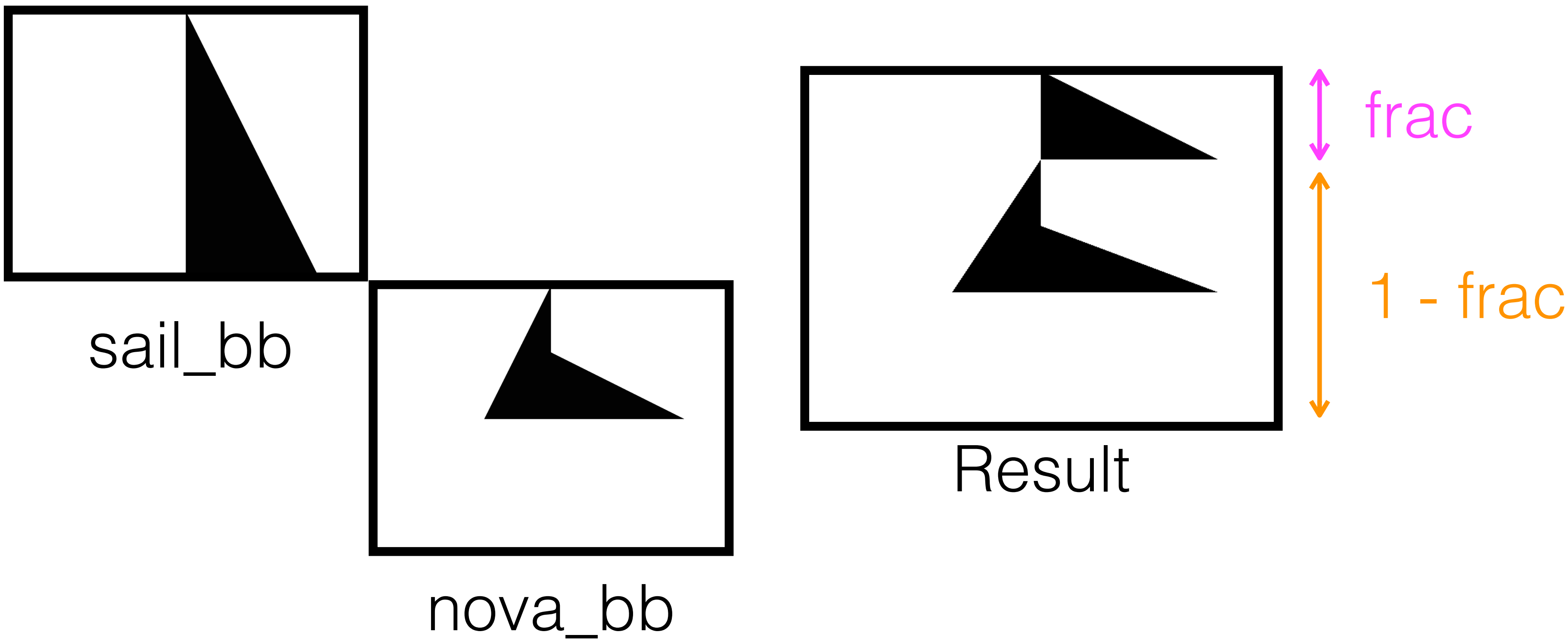
Result



stack_frac

Op frac Rune 1 Rune 2

```
show(stack_frac(1/4, sail_bb, nova_bb))
```

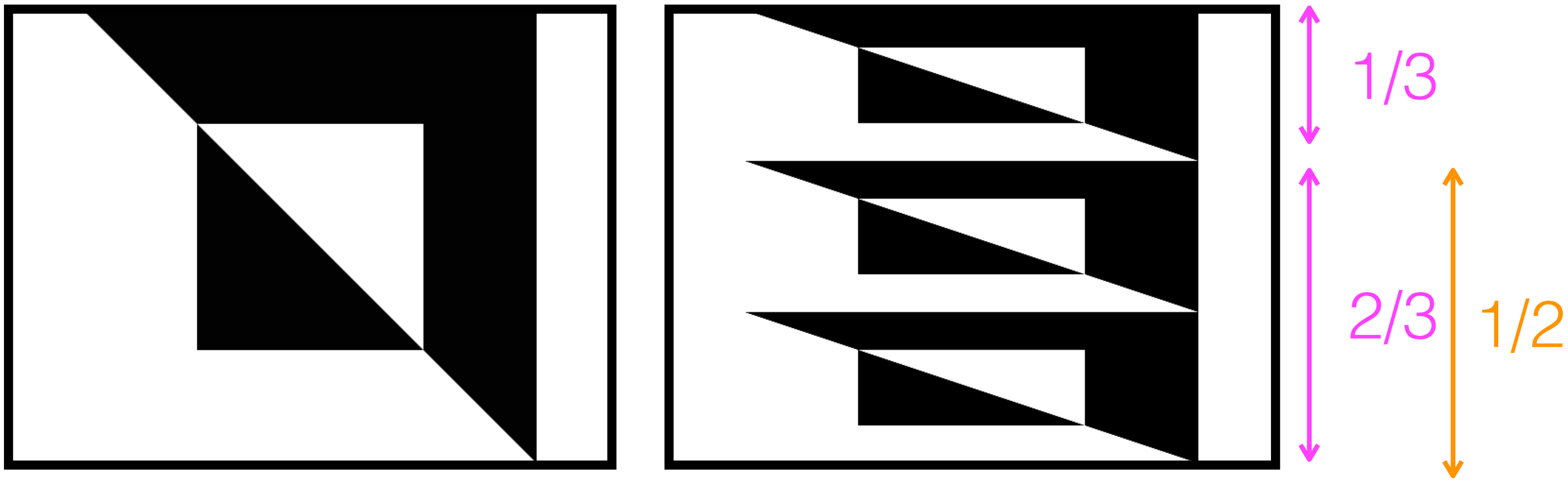


Stack 3 rows evenly

Op frac

show(stack_frac(1/3,
rcross_bb,
stack(rcross_bb, rcross_bb)))

Op Rune 1 Rune 2



rcross_bb

Result

Hands on

- stackn(n, rune)
  - n = Number of times to stack
  - rune = image to stack
- Each rune height is 1/n of the entire height

Stack n rows evenly

Recursive solution

```
function stackn(n, rune) {
    if (n == 1) {
        return rune;
    } else {
        return stack_frac(1/n,
                          rune,
                          stackn(n-1, rune));
    }
}
```

Stack n rows evenly

Iterative solution

```
function stackn(n, rune) {
    var result = rune;
    var current_frac = 1;
    while (current_frac <= n) {
        result = stack_frac(1/current_frac, rune, result);
        current_frac = current_frac + 1;
    }
    return result;
}
```

Functional Abstraction

No idea how a picture is represented

Functional Abstraction

No idea how the operations
do their work

Functional Abstraction

Yet we can build
complex pictures

That’s it?

Nope!

More cool stuff in next session

Homework

- Refer to handout for quick reference
- Download the Runes zipped folder from Dropbox (refer to slides behind for the following functions)
  - **mosaic**(rune1, rune2, rune3, rune4)
  - **simple_fractal**(rune)
  - **fractal**(rune, n)
- Email me your code in “.txt” format by **Sunday 15th Mar 2014**

Instructions on doing HW

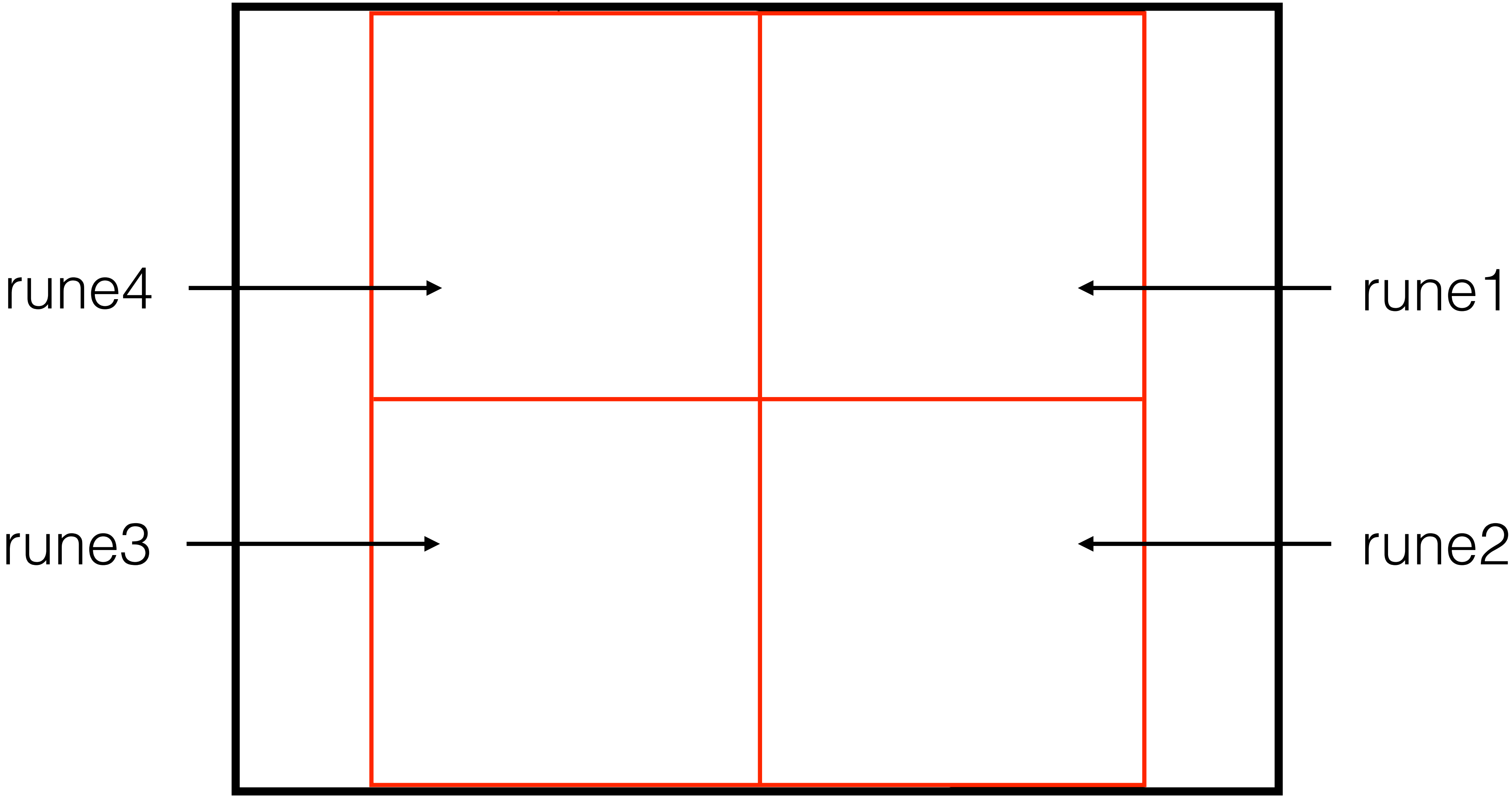
- Don’t touch anything except **ctc.js**
- Fill in the functions in **ctc.js** (Using notepad)
- Save your changes
- Open **ctc.html** using Firefox / Refresh after changes
- Open Firefox console
- Test!

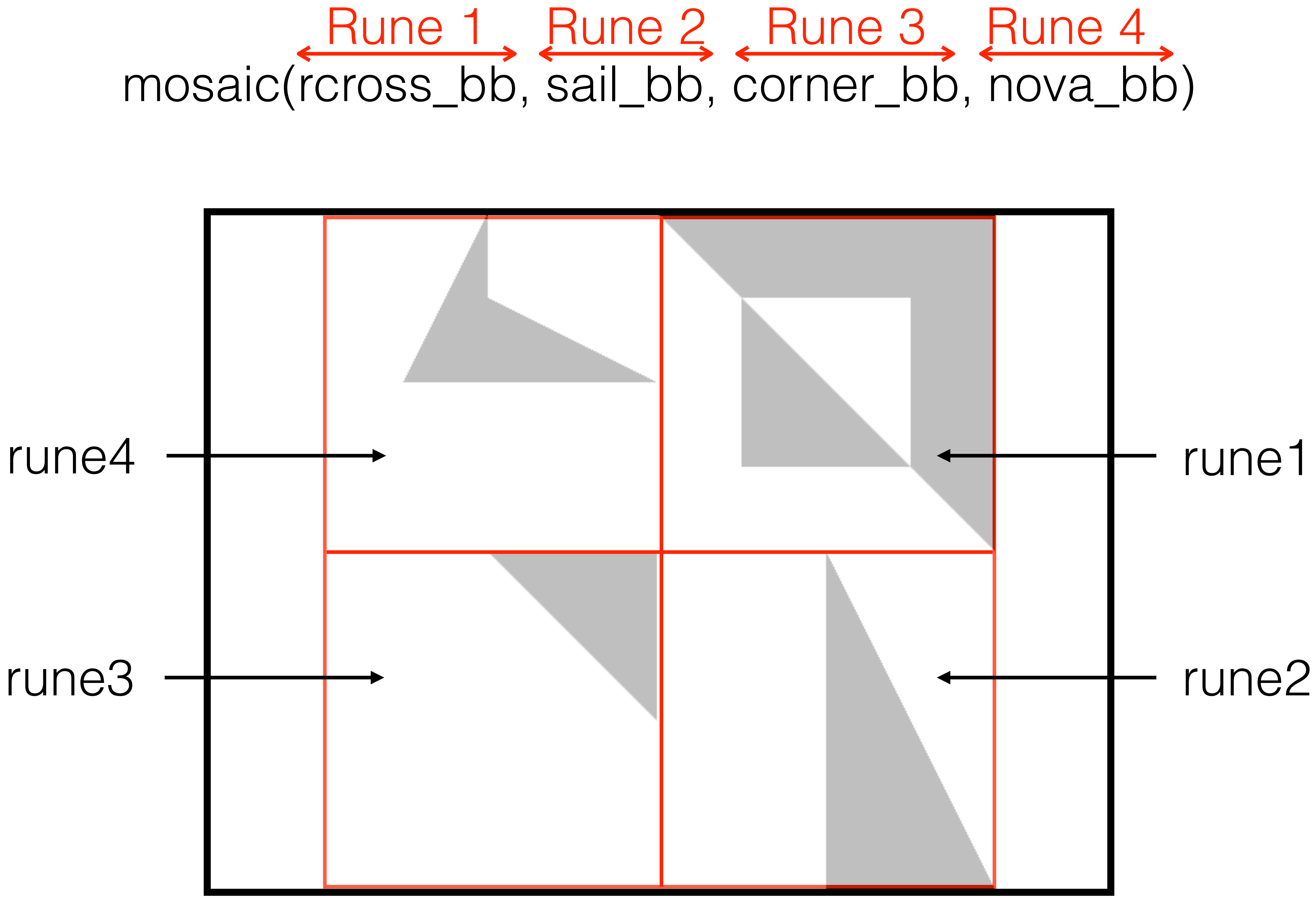
Reminder

No session next week (19th March)

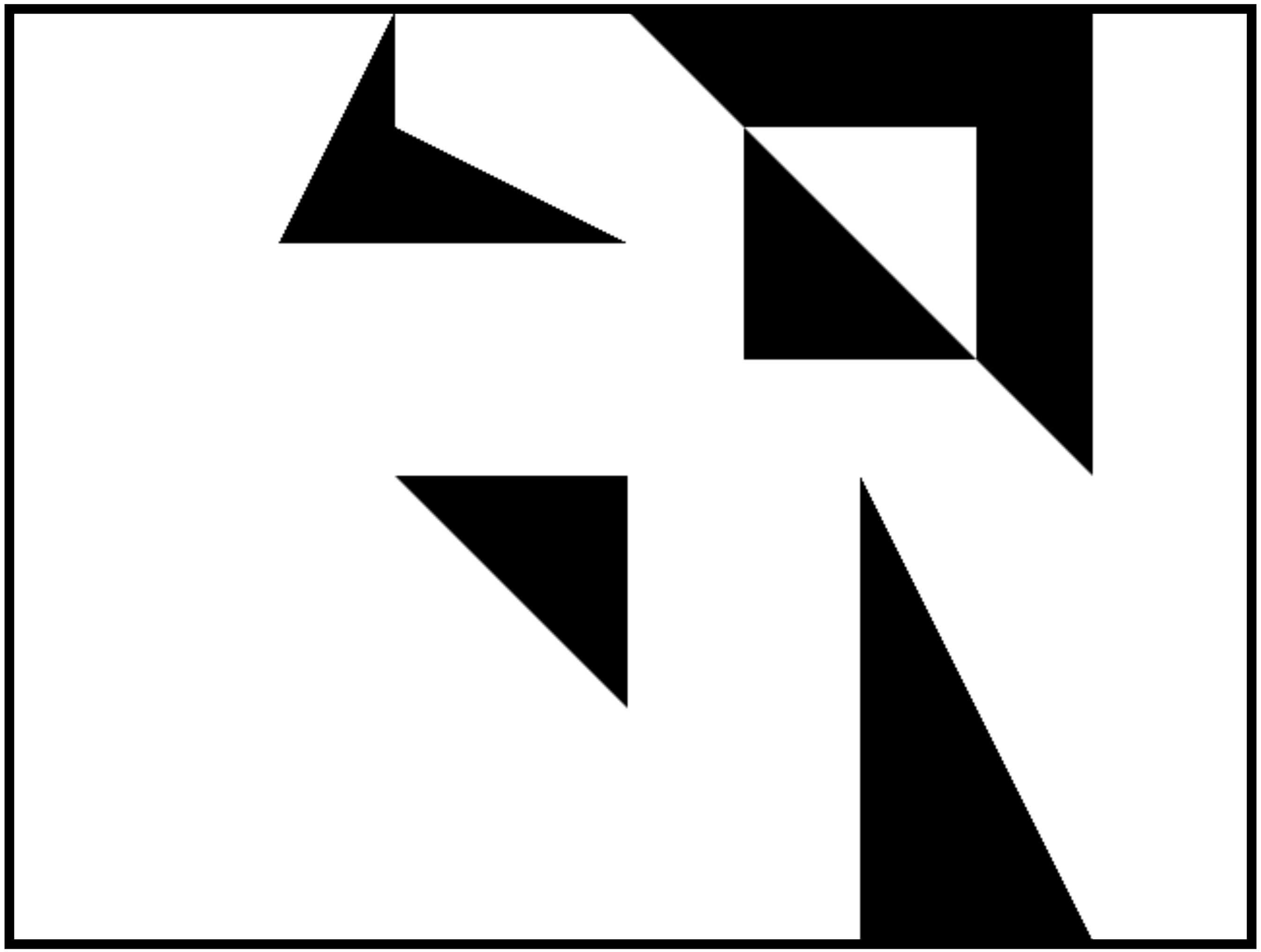
Next session will be 26th March (Wed)

mosaic(rune1, rune2, rune3, rune4)

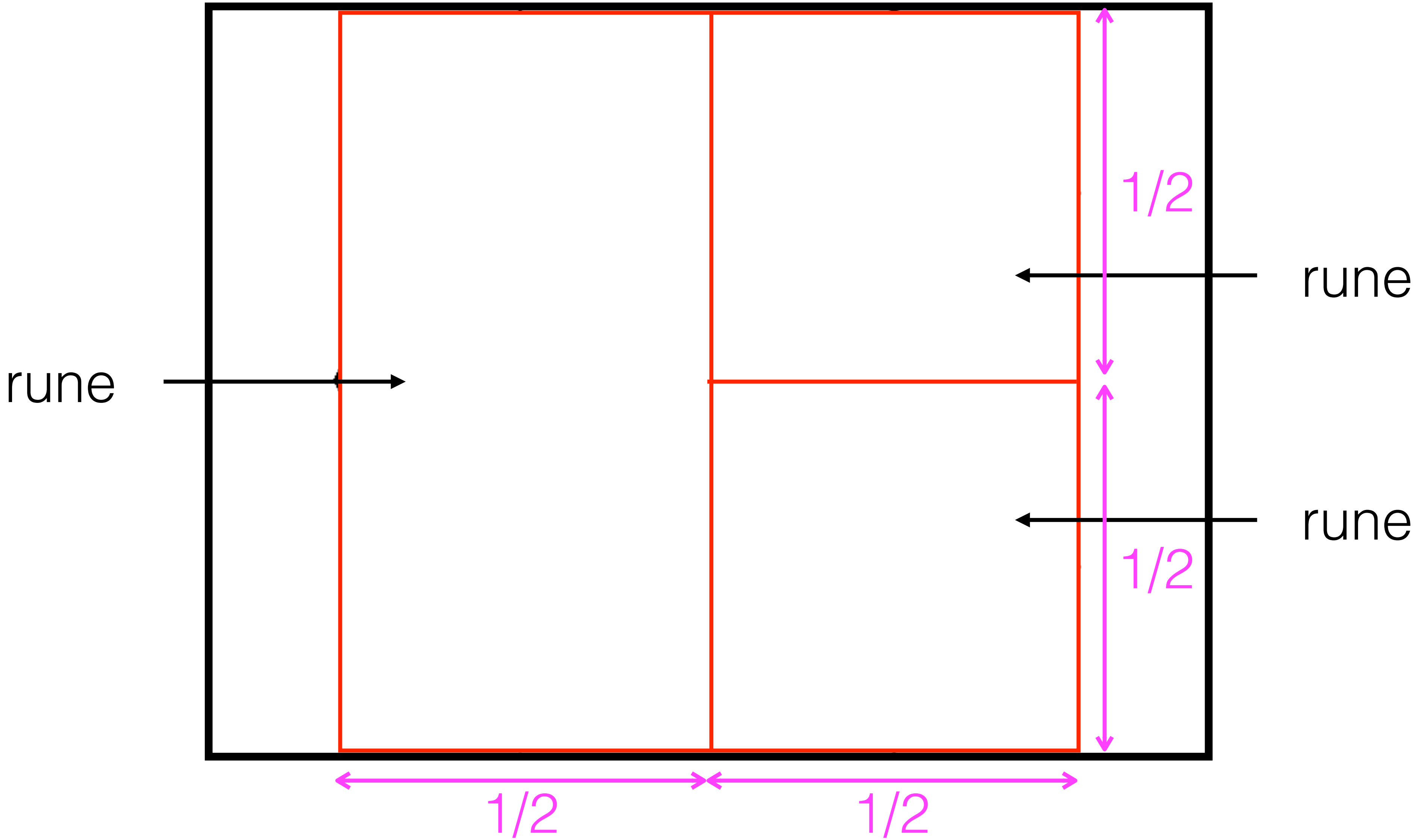



Rune 1
Rune 2
Rune 3
Rune 4
mosaic(rcross_bb, sail_bb, corner_bb, nova_bb)
rune4
rune1
rune3
rune2

mosaic(rcross_bb, sail_bb, corner_bb, nova_bb)

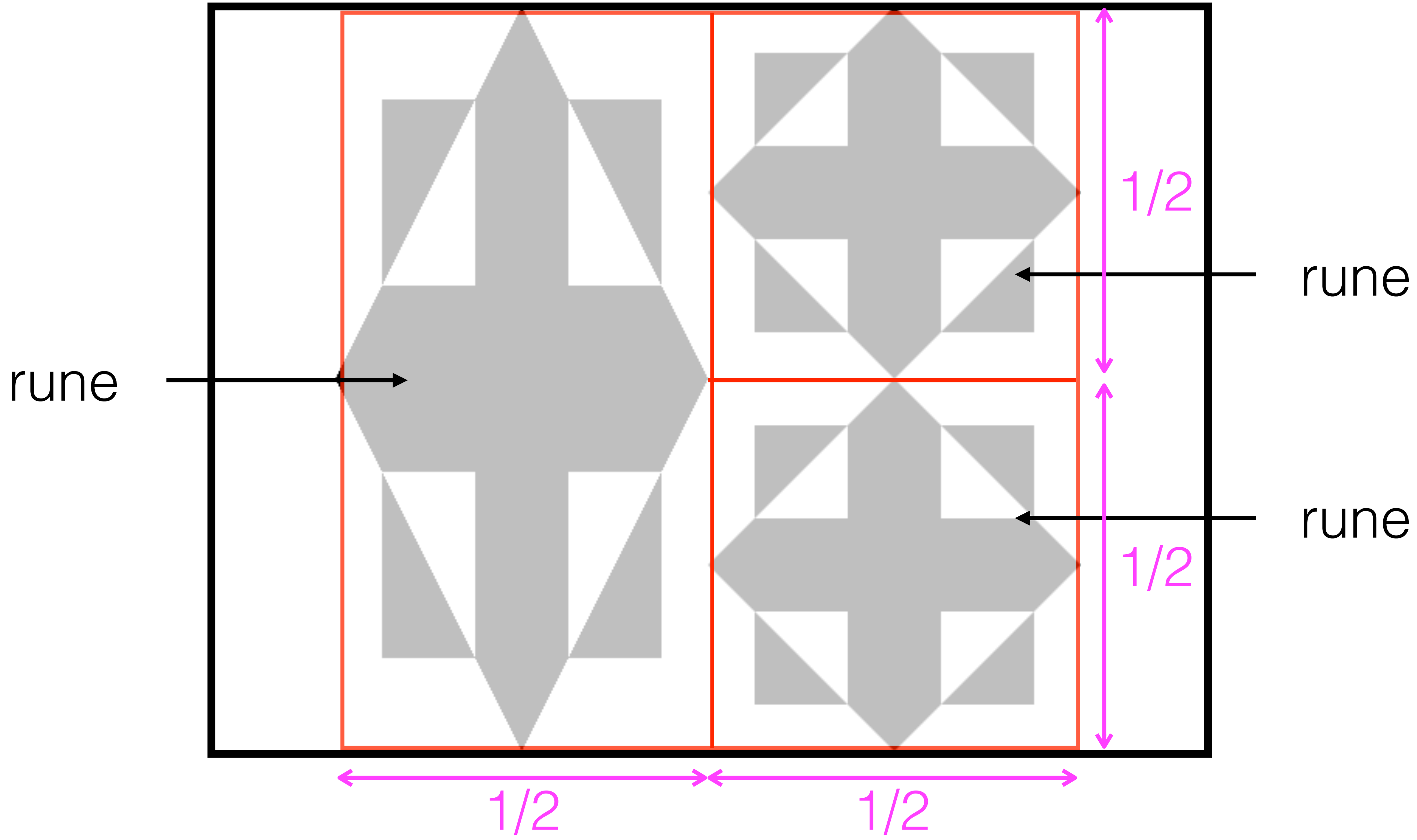


simple_fractal(rune)

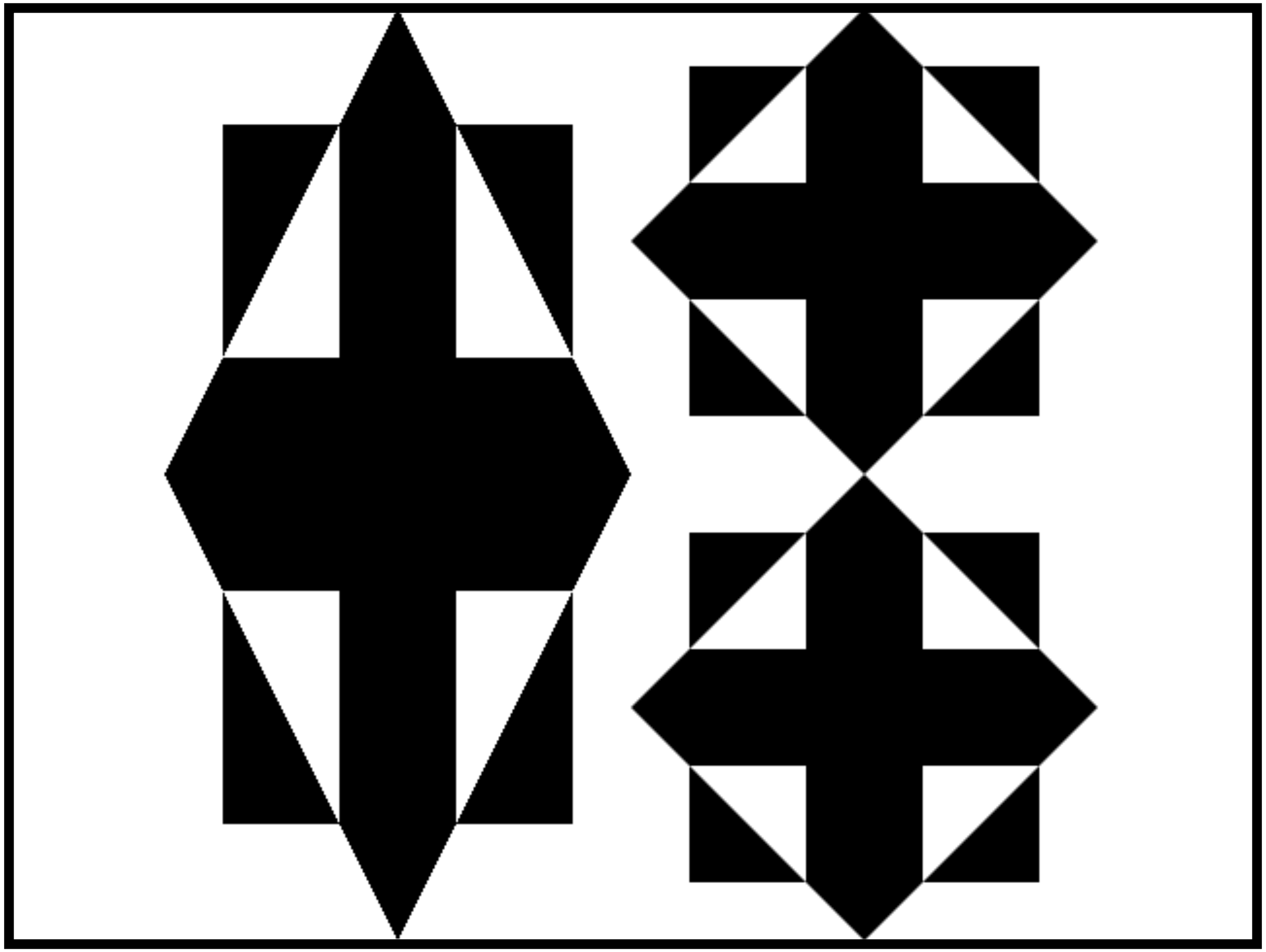


Rune

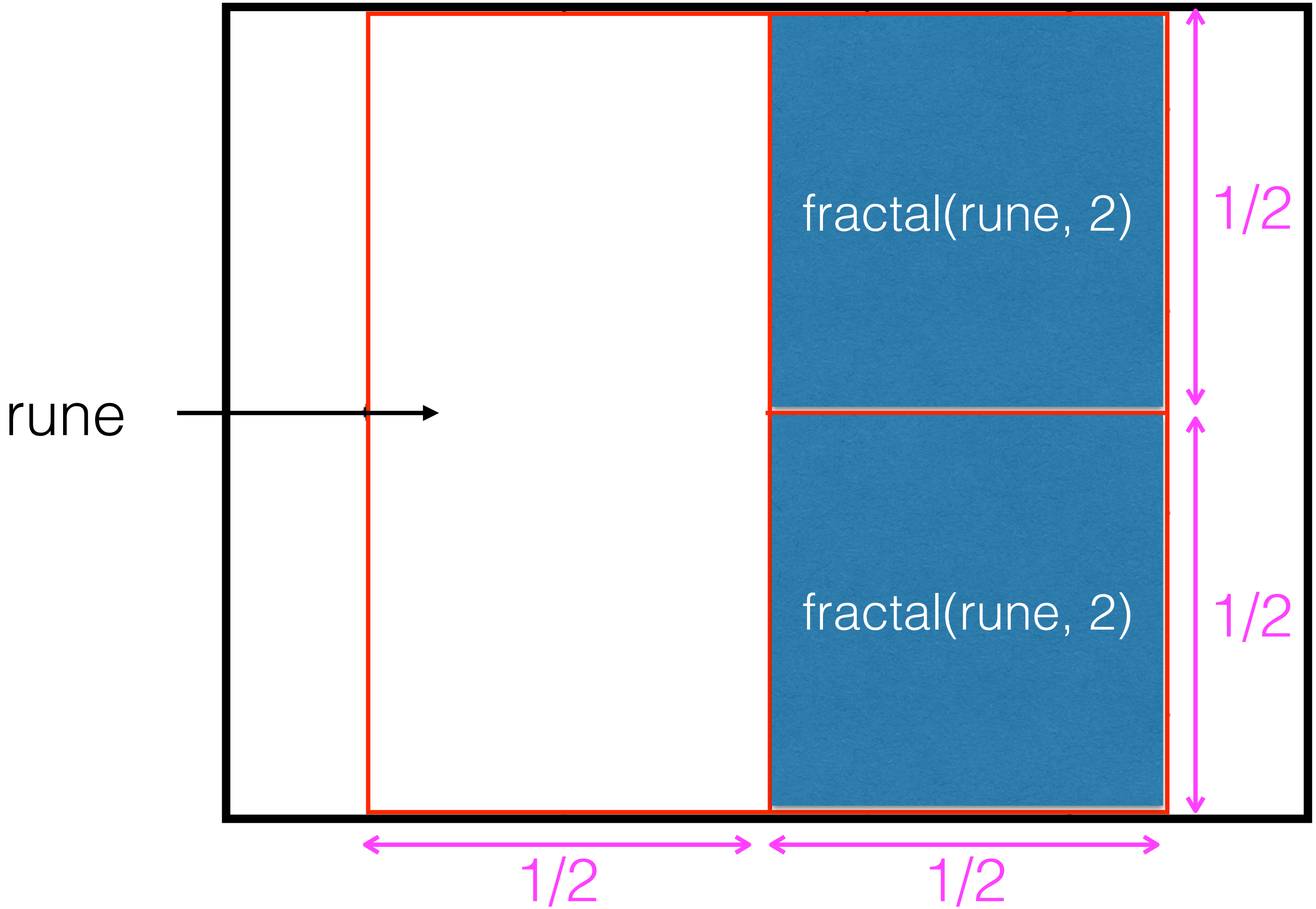
simple_fractal(make_cross(rcross_bb))



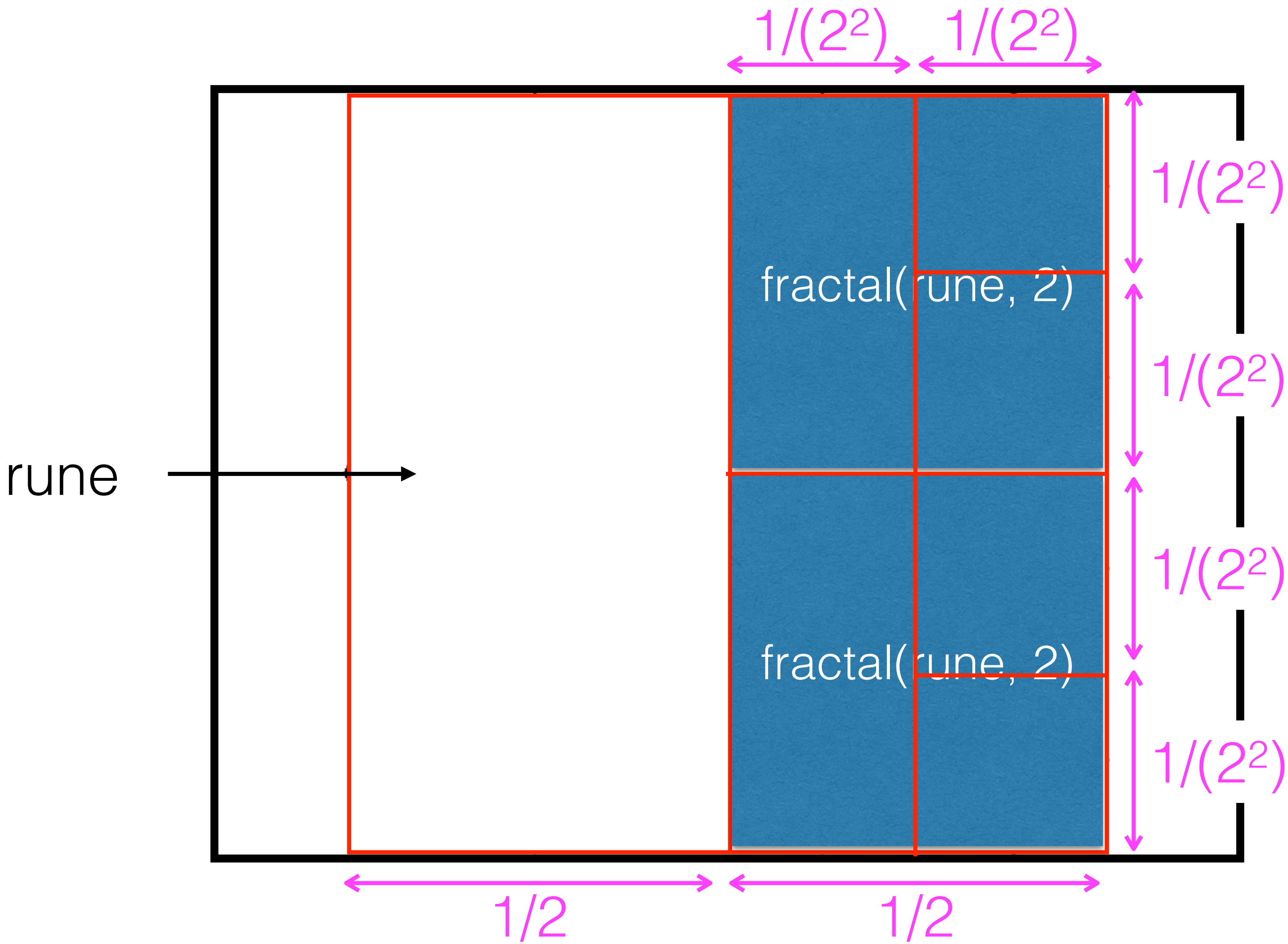
simple_fractal(make_cross(rcross_bb))



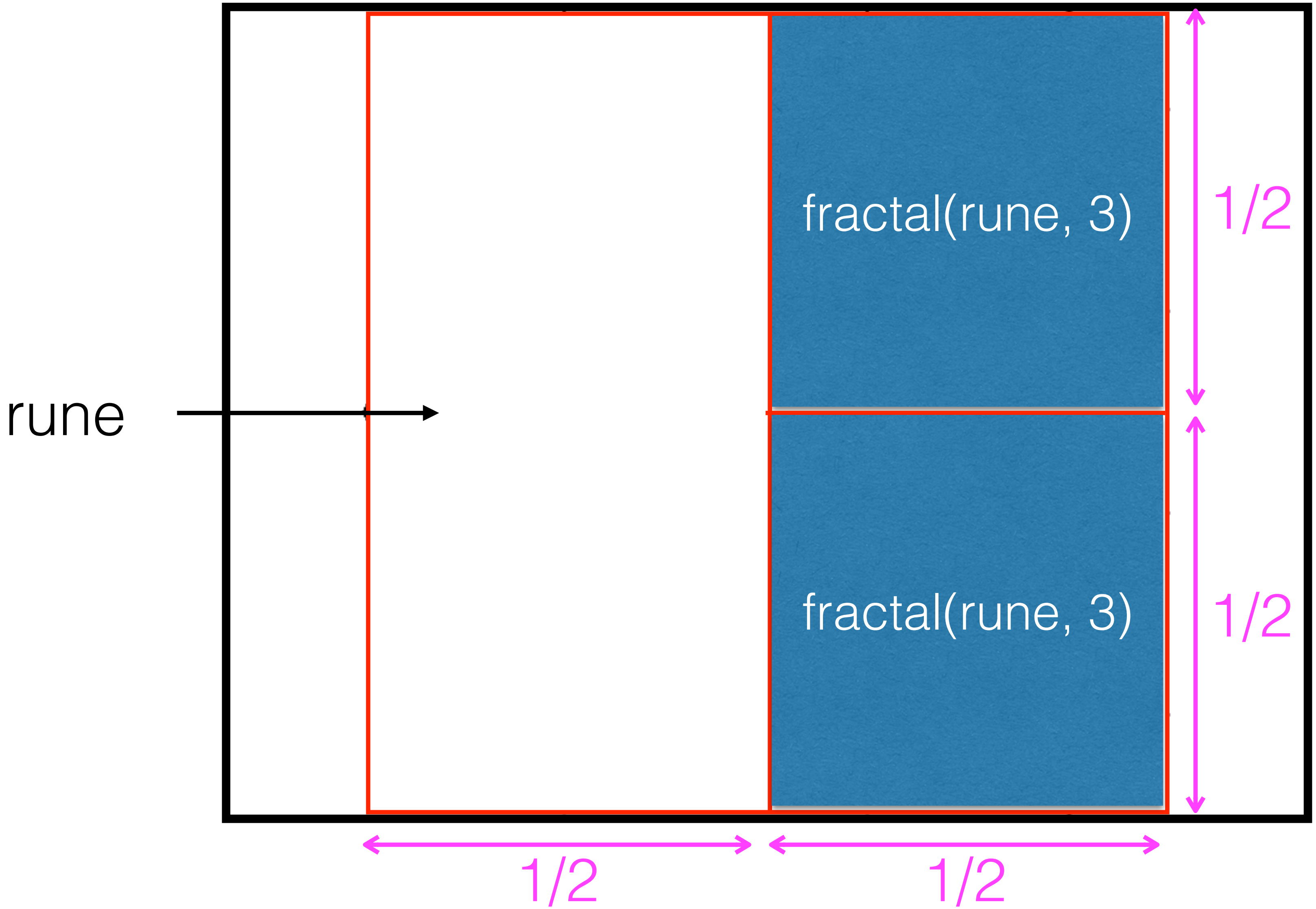
fractal(rune, 3)



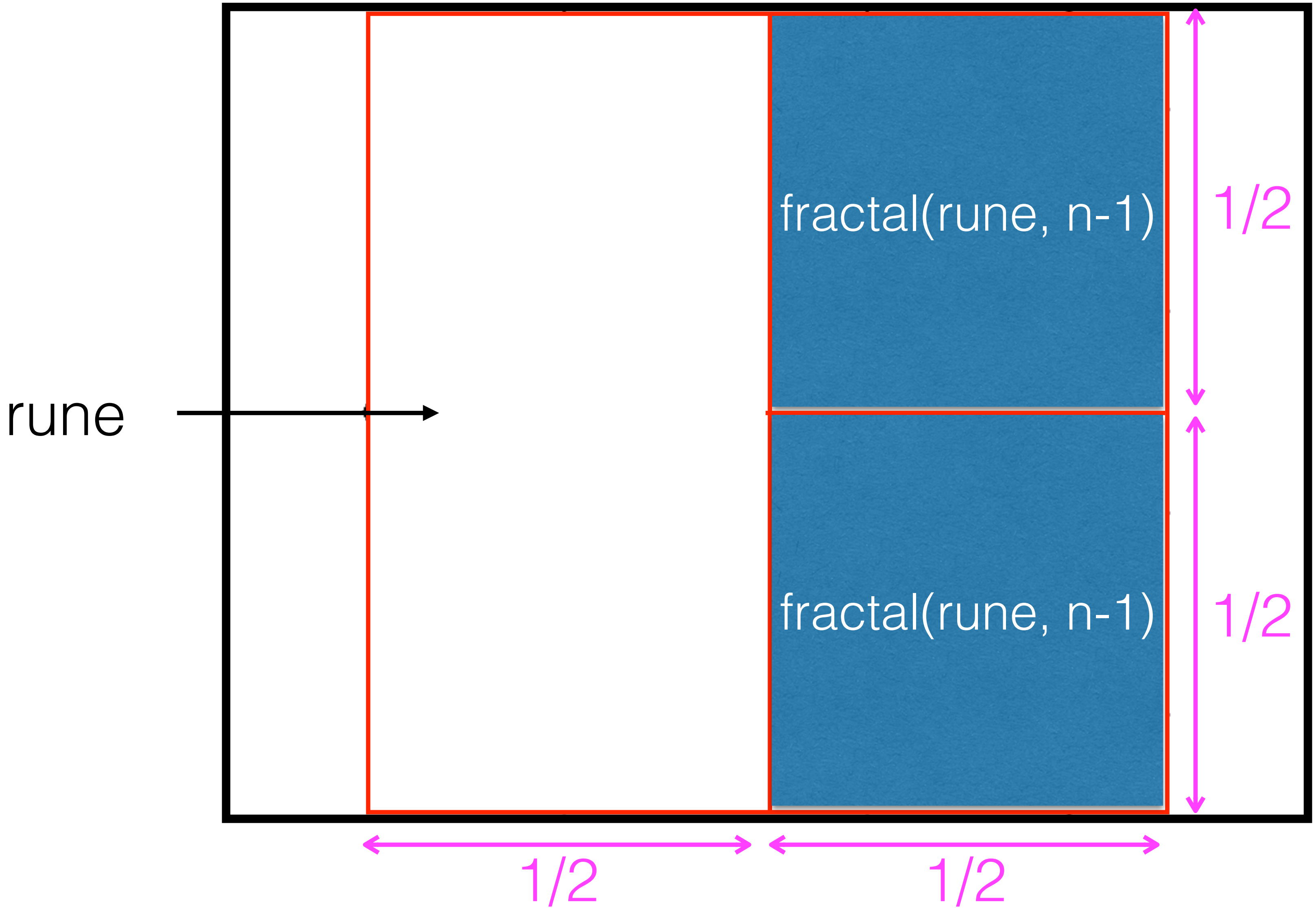
fractal(rune, 3)



fractal(rune, 4)

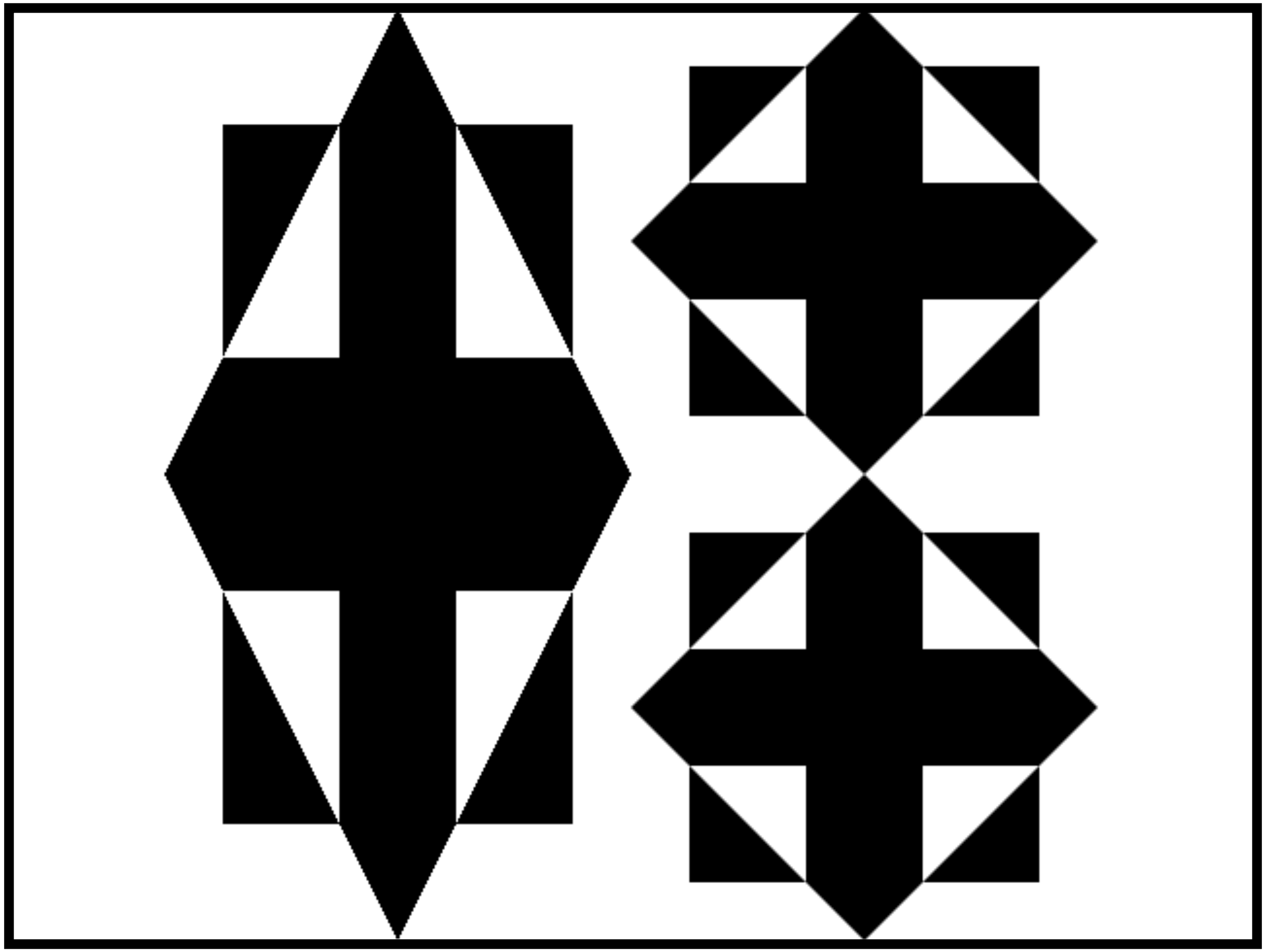


fractal(rune, n)



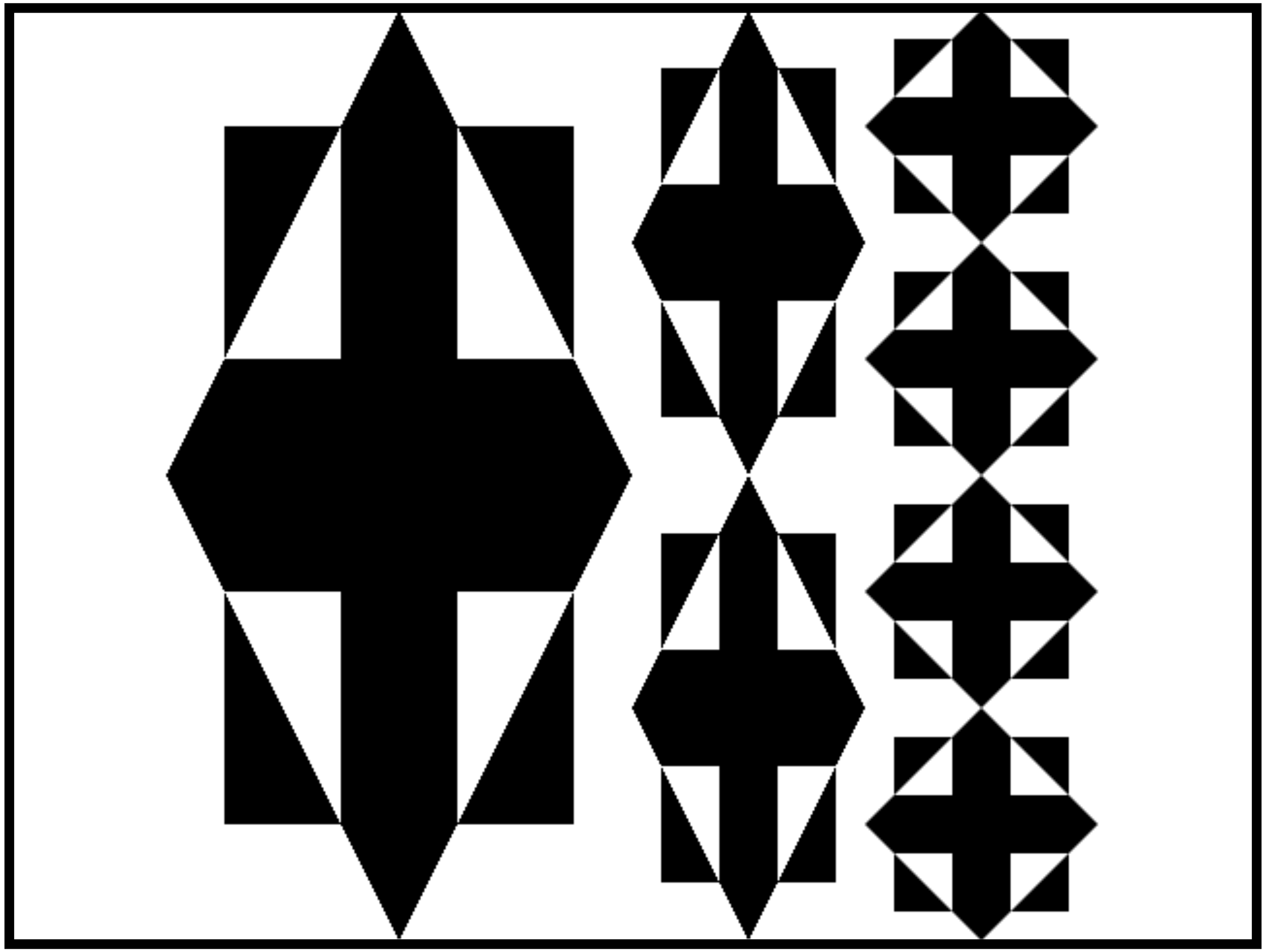
Rune n

fractal(make_cross(rcross_bb), 2)



simple_fractal(rune) = fractal(rune, 2)

fractal(make_cross(rcross_bb), 3)



Computational Thinking

Temasek Junior College

Davin Choo
cxjdavin+CTC@gmail.com

TEMASEK
JUNIOR COLLEGE

Welcome back!

- Hope you enjoyed your holidays!
  - Any interesting stories to share with the class? ;)
- What have we done so far?
- What will we be doing next?

Modelling

- Basic graph model
- Modelling real life problems into numbers

Problem solving techniques

- Iteration
- Recursion
- Abstraction / Decomposition of large problems

Technical knowledge

- How to read and write
    - Pseudocode
    - Basic Javascript
- What’s “testing”, and how to do it
- Data structure: Array

Specific algorithms

- Factorial
- Swap
- Find max
- Binary Search

Recap Learning Objectives

- When given a problem, know how to get started
- “So what did you learn?”
  - Life is complex
  - **Manage complexity!**
- Basic programming skills to implement solutions
- *Programming is the language of the future*

Ready for next term?

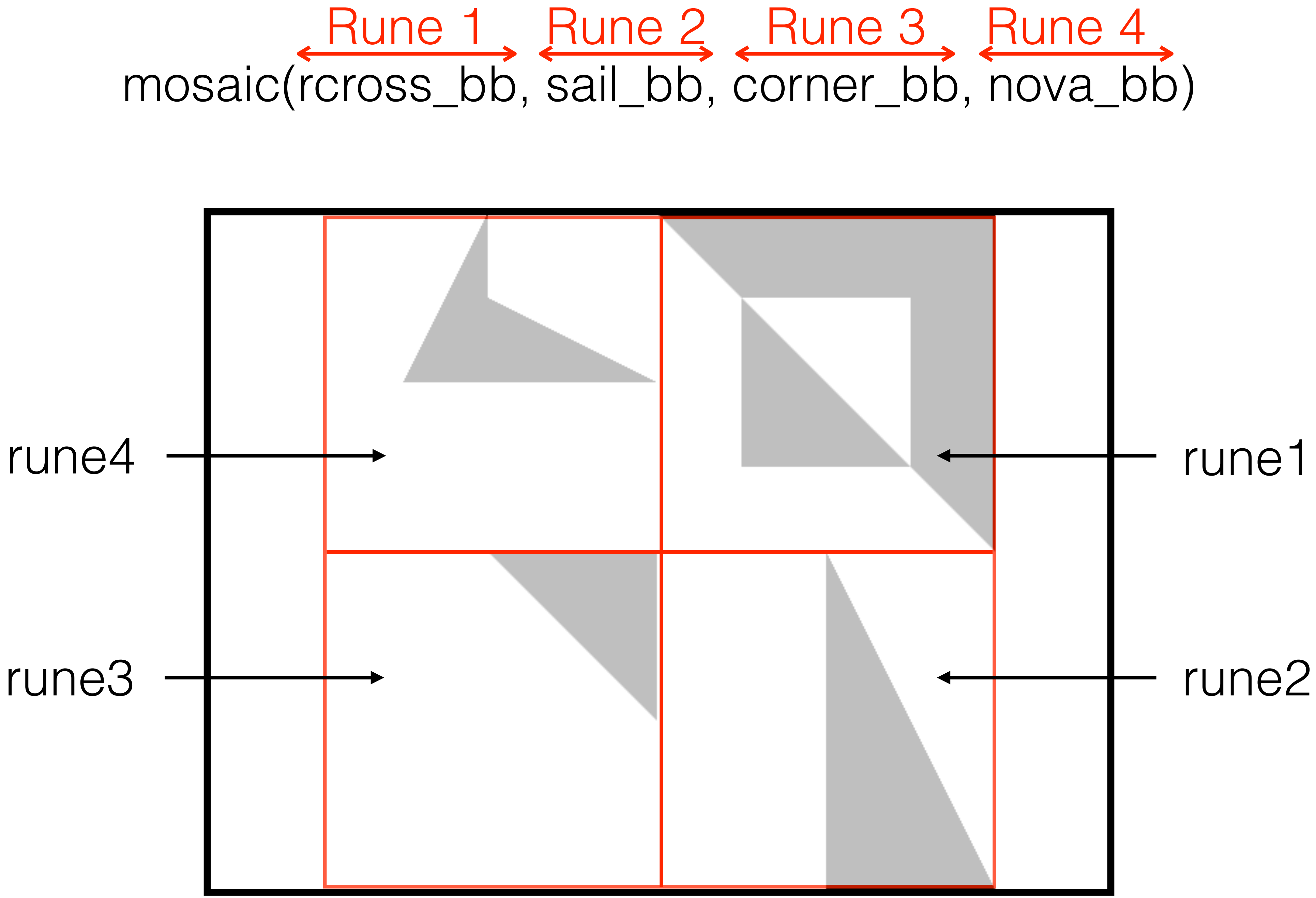
- Compulsory
  - Basic sorting
- Topics by voting
  - Vote later today

Today’s Plans

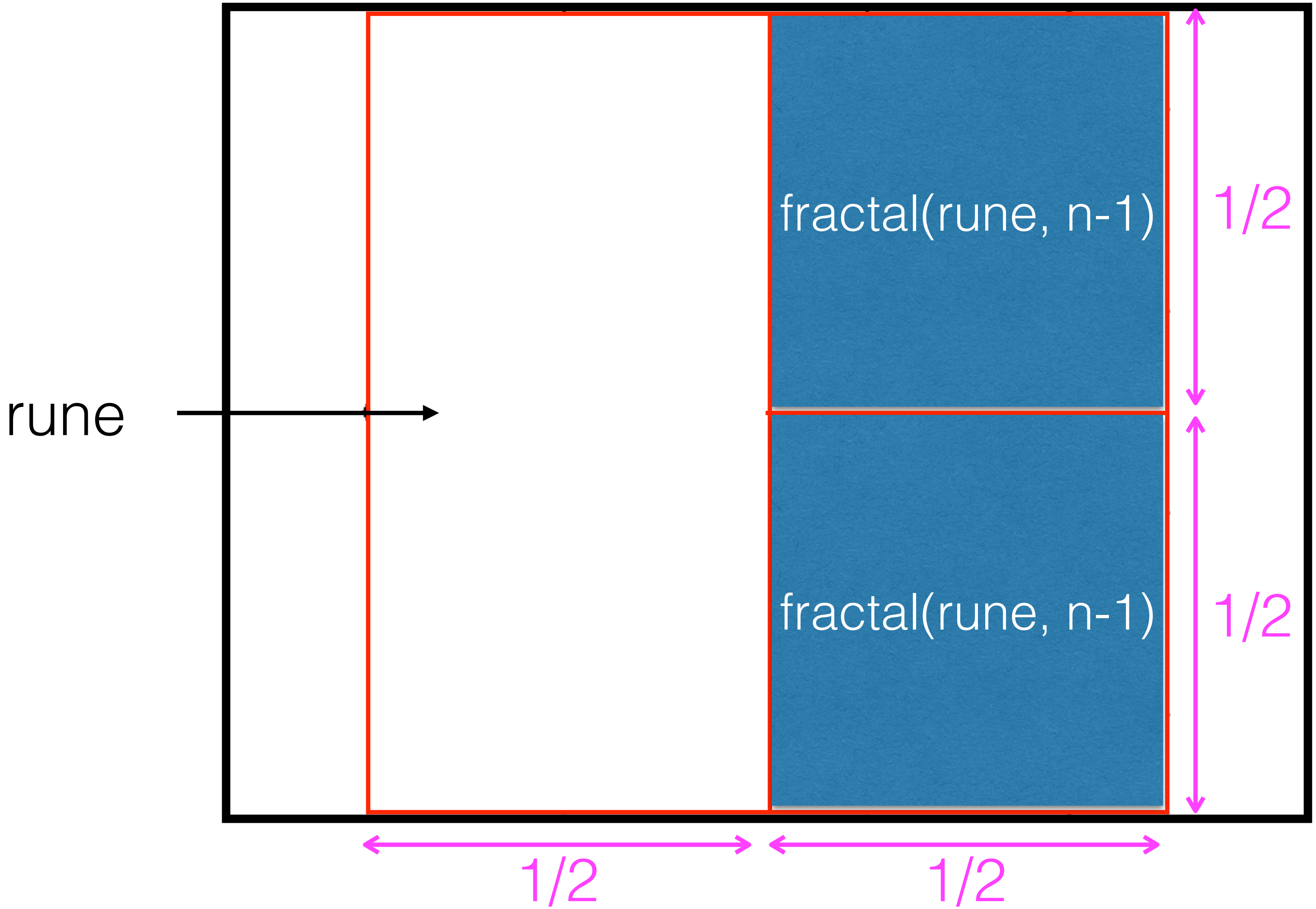
- Finish up on Runes
- Share some technical interview questions
- Vote on topics
    - Starts after sorting

Homework

- Refer to handout for quick reference
- Download the Runes zipped folder from Dropbox (refer to slides behind for the following functions)
  - **mosaic**(rune1, rune2, rune3, rune4)
  - **simple_fractal**(rune)
  - **fractal**(rune, n)
- Email me your code in ".txt" format by **Sunday 15th Mar 2014**


Rune 1
Rune 2
Rune 3
Rune 4
mosaic(rcross_bb, sail_bb, corner_bb, nova_bb)
rune4
rune3
rune1
rune2

fractal(rune, n)



Persian rug / carpets

Persian carpet

From Wikipedia, the free encyclopedia

The **Persian carpet** or **Persian rug** (Middle Persian: *bōb*,[1] Persian: فرش *farsh*, meaning "to spread"; sometimes قالی *qālī*)[2] is an essential part of Persian art and culture. Carpet-weaving is undoubtedly one of the most distinguished manifestations of Persian culture and art, and dates back to ancient Persia. In 2008, Iran's exports of hand-woven carpets was $420 million or 30% of the world's market.[3][4] There is an estimated population of 1.2 million weavers in Iran producing carpets for domestic markets and international export.[5] Iran exports carpets to more than 100 countries, as hand-woven rugs are one of its main non-oil export items. The country produces about five million square metres of carpets annually—80 percent of which are sold in international markets.[6] In recent times Iranian carpets have come under fierce competition from other countries producing reproductions of the original Iranian designs as well as cheaper substitutes.[6]

The designs of Persian carpets are copied by weavers from other countries as well. Iran is also the world's largest producer and exporter of handmade carpets, producing three quarters of the world's total output.[7][8][9] Though in recent times, this ancient tradition has come under stiff competition from machine-made products.[10] Iran is also the maker of the largest handmade carpet in history, measuring 60,546 square feet (5,624.9 square metres).[11][12][13]

Persian carpets can be divided into three groups; **Farsh** / **Qāli** (sized anything greater than 6×4 feet), **Qālicheh** (قالیچه, meaning "small rug", sized 6×4 feet and smaller), and nomadic carpets known as ***Gelim*** (گلیم; including زیلو *Zilu*, meaning "rough carpet").[2] In this use, Gelim includes both pile rugs and flat weaves (such as kilim and soumak).

Contents [hide]

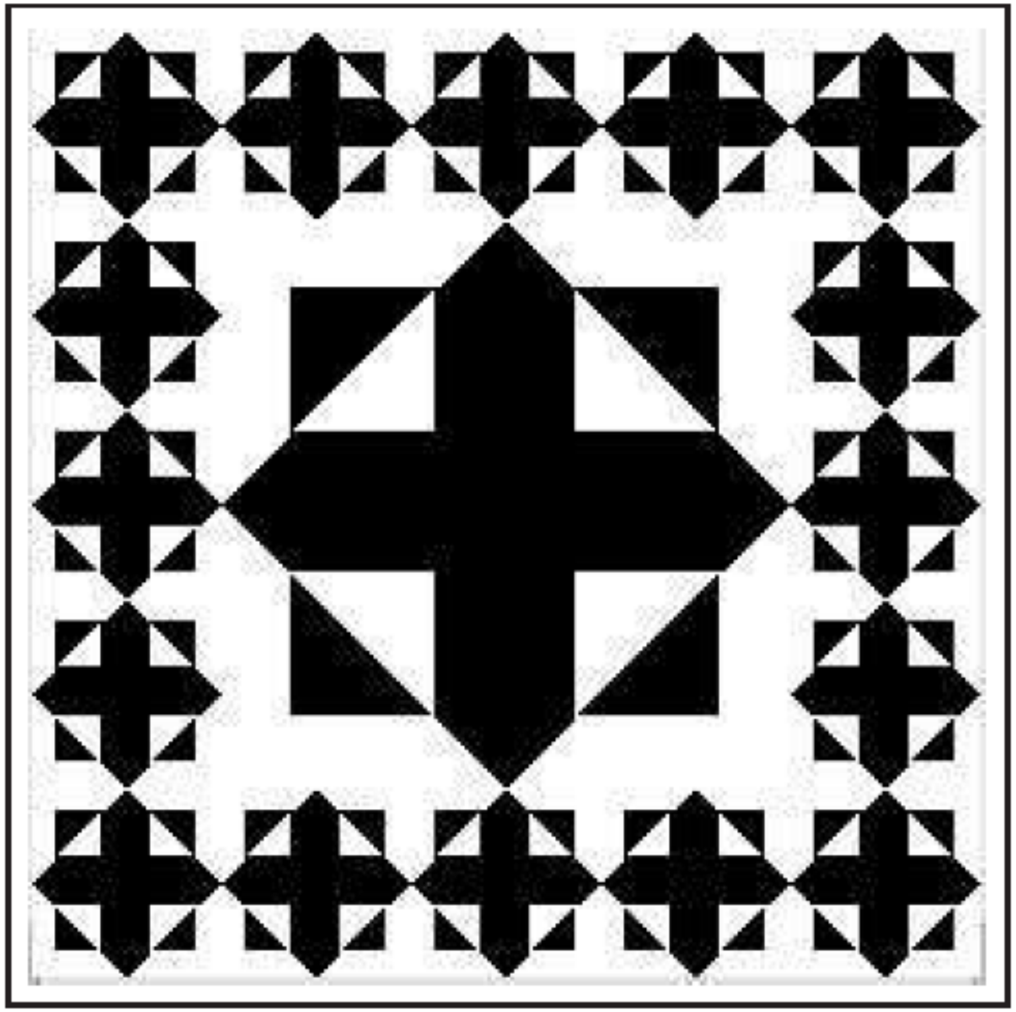
The Rothschild Small Silk Medallion Carpet, mid-16th century, Museum of Islamic Art, Doha (enlarge image to see detail)

http://en.wikipedia.org/wiki/Persian_carpet

persian(rune, n)

How do we build this?

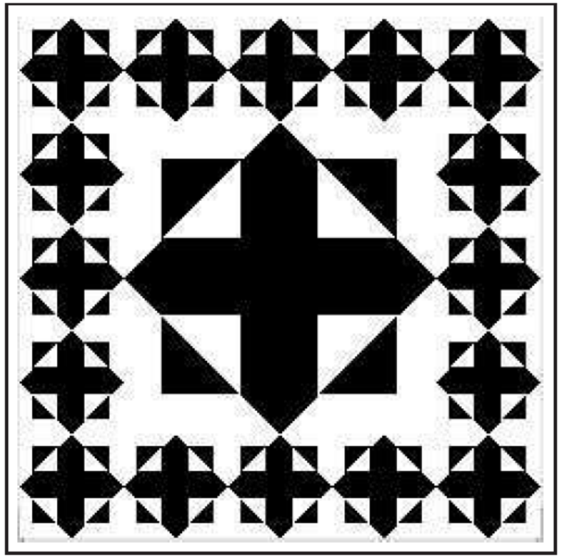
n = 5

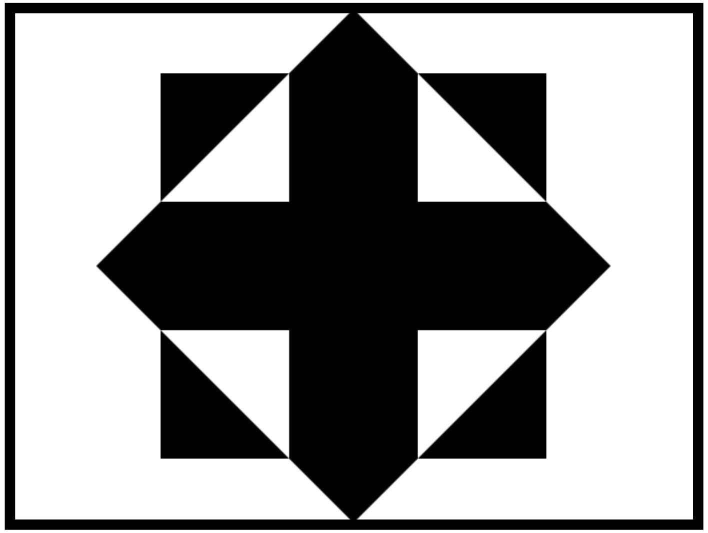


Break it down into **smaller parts** that you know how to solve!

Apply what you have learnt!

What small part do you know how to solve?



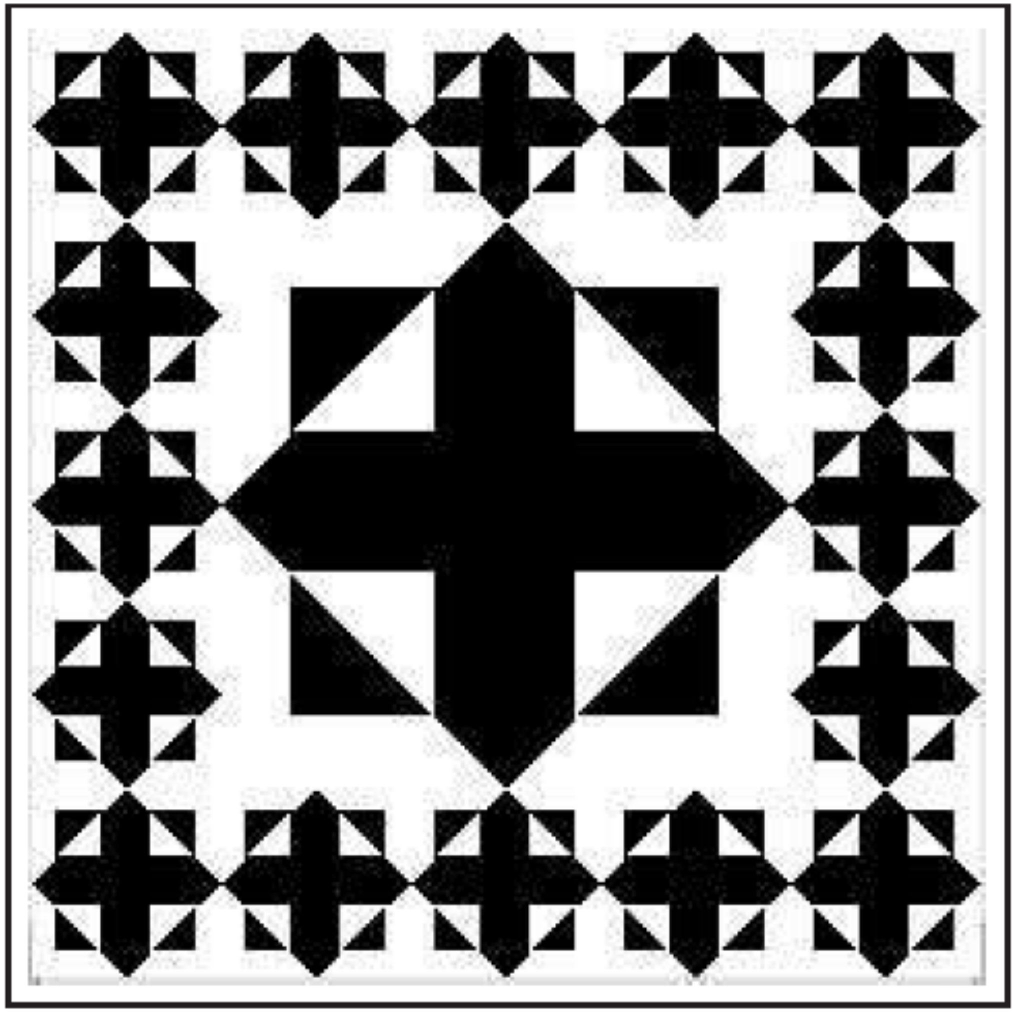


make_cross

stacking: stack_frac, stackn

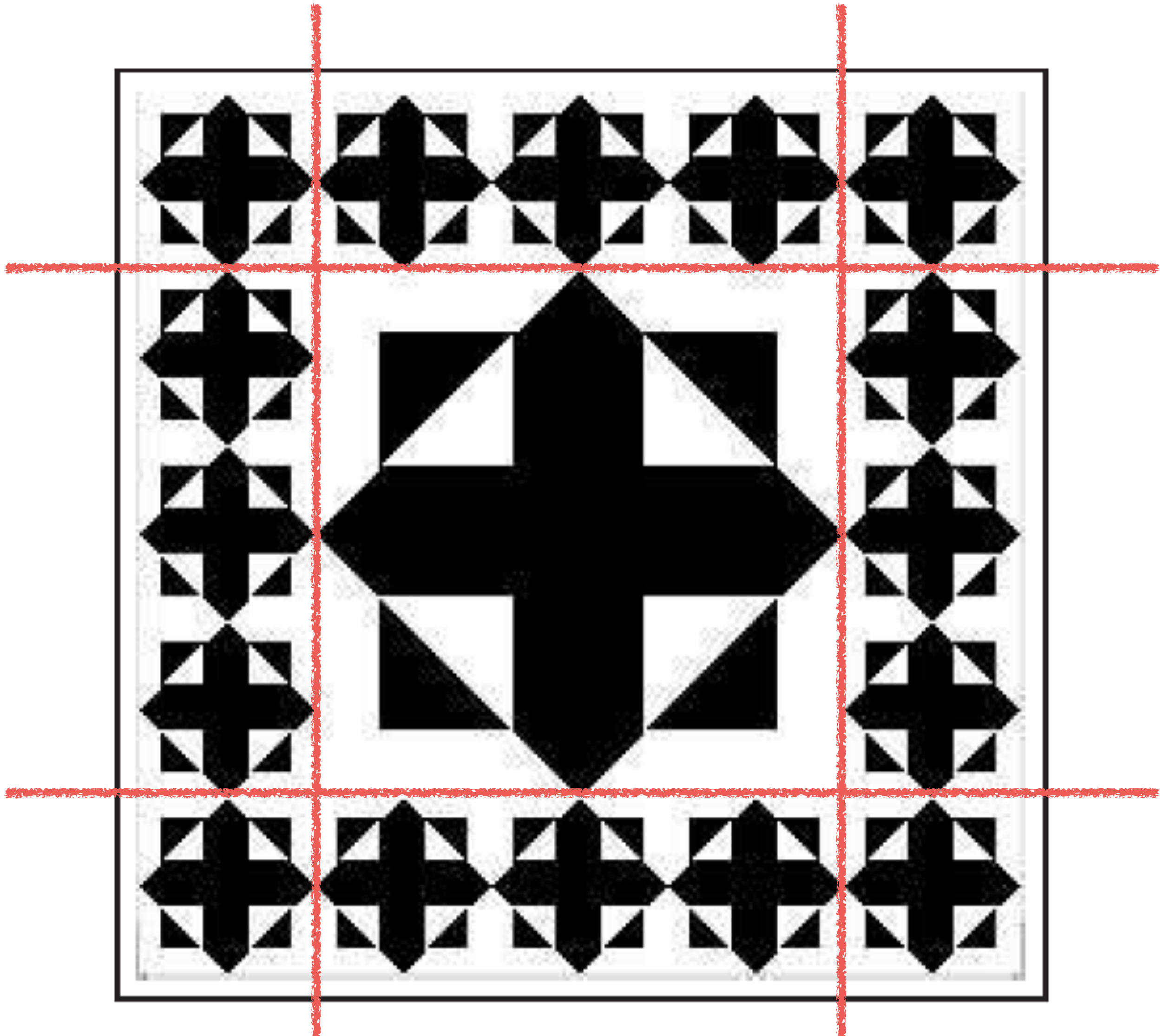
rotating: quarter_turn_left, quarter_turn_right

Decomposition the problem



How do we split this?

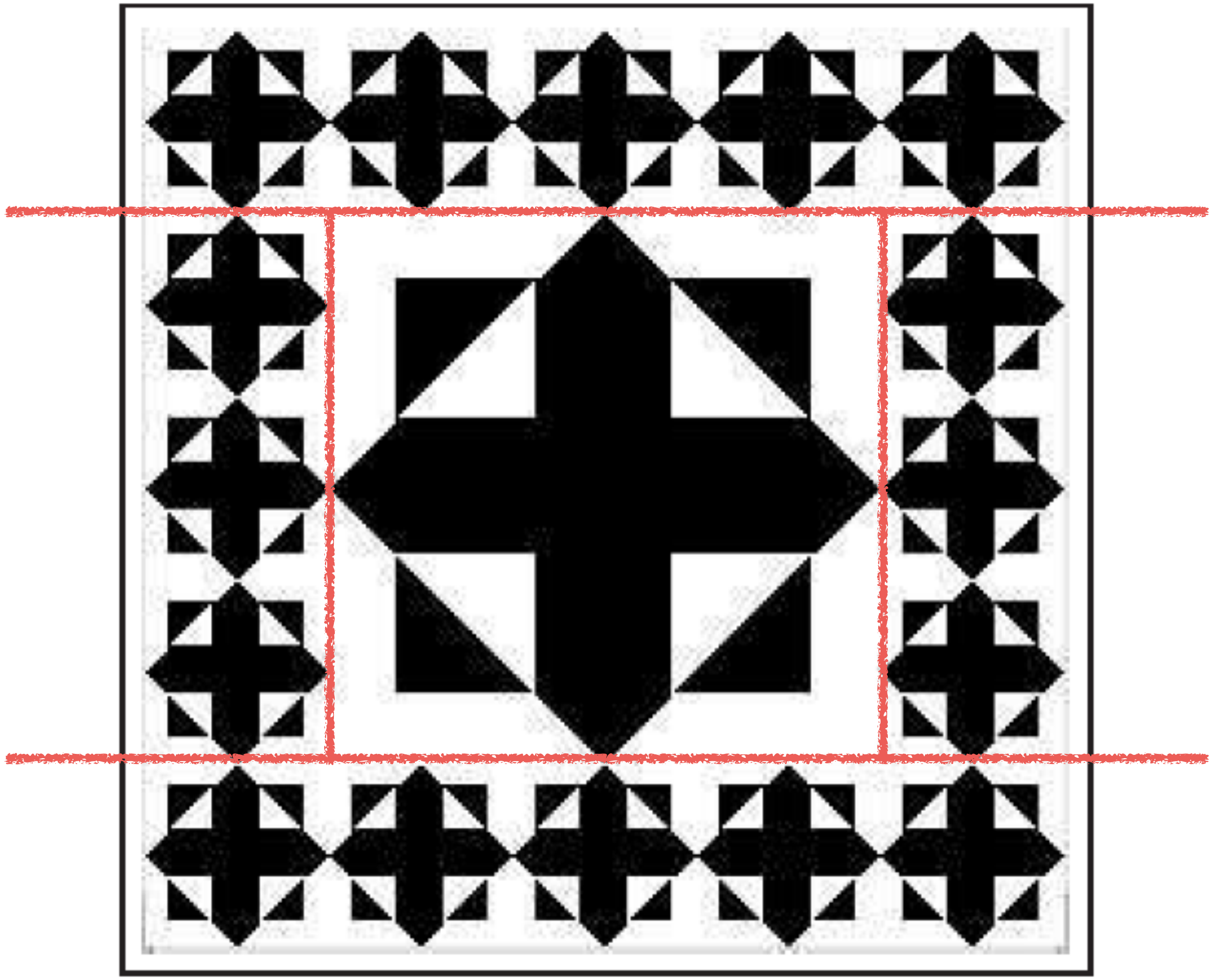
Decomposition #1



What do we use here?

How do we split this?

Decomposition #2



What do we use here?

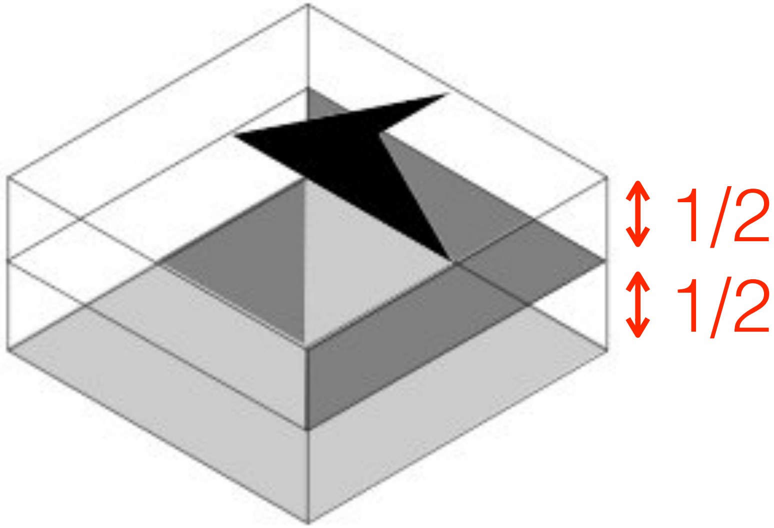
How do we split this?

Creating 3D Objects

- Use greyscale to represent depth
- Surface = Black
  Maximum depth = White
  - Closer to you = Blacker
    Further from you = Whiter

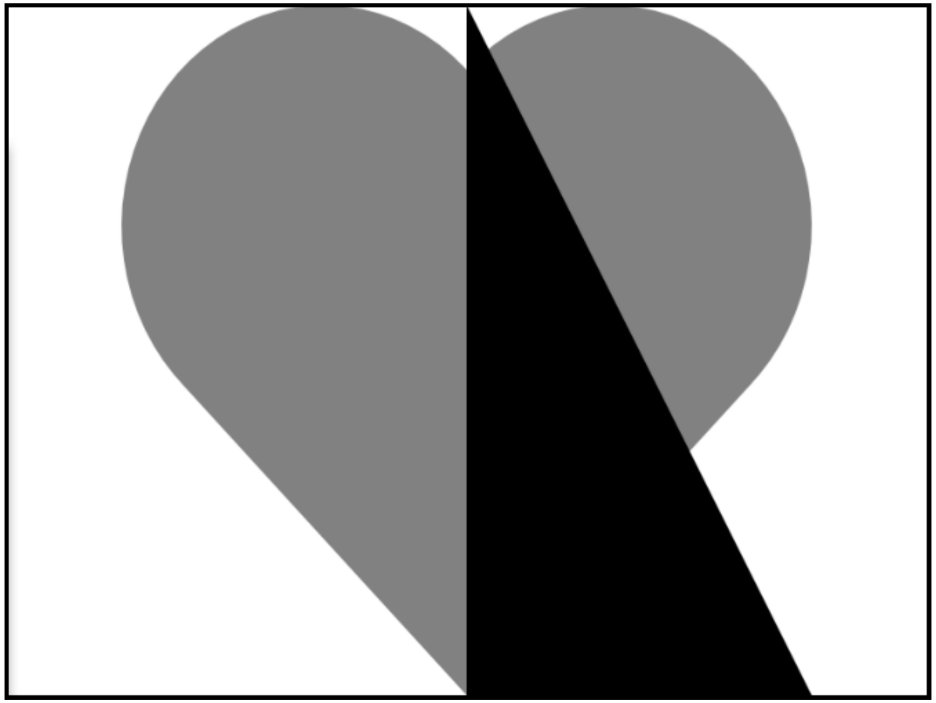
Creating 3D Objects

means

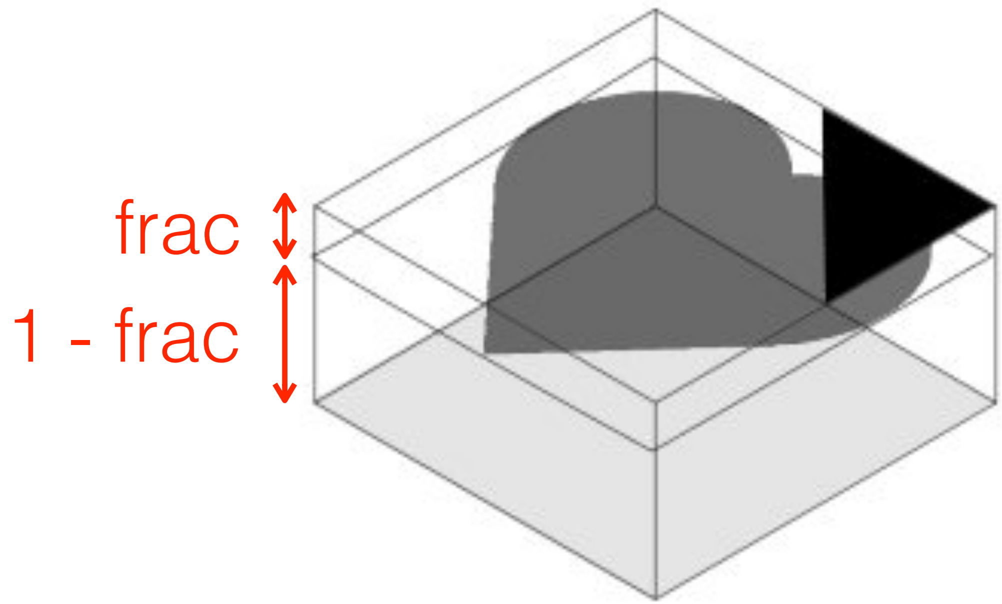


Creating 3D Objects

- overlay(sail_bb, heart_bb)

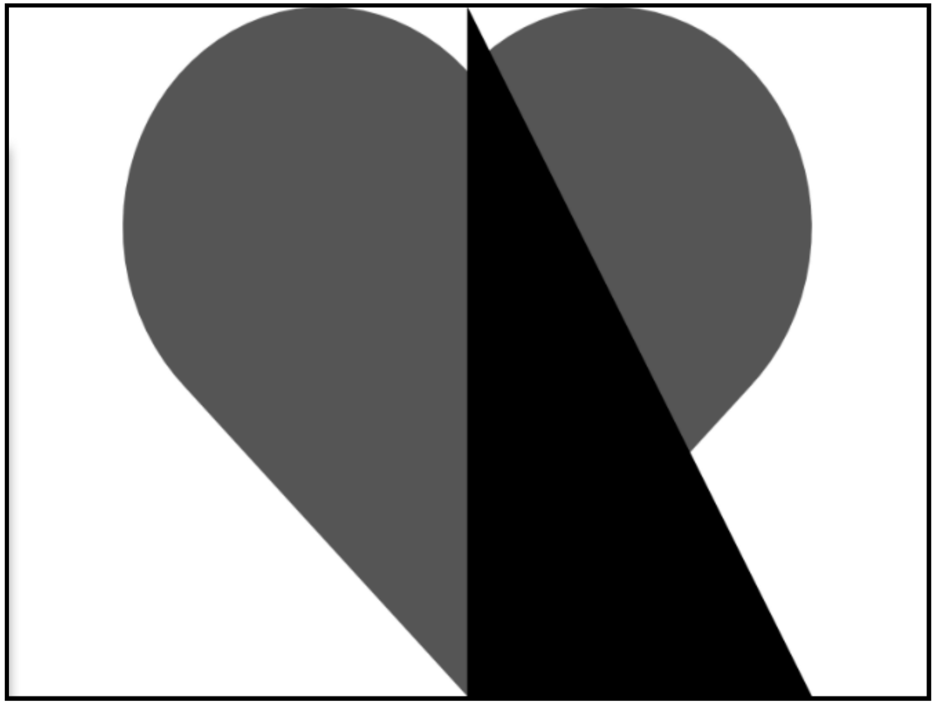


Of course there's overlay_frac



Creating 3D Objects

- overlay_frac(1/3, sail_bb, heart_bb)



Other cool stuff you can do

- **anaglyph** E.g. anaglyph(sail_bb)
  - http://en.wikipedia.org/wiki/Anaglyph_3D
- **stereogram** E.g. stereogram(sail_bb)
  - http://en.wikipedia.org/wiki/Stereogram
- **hollusion** E.g. hollusion(sail_bb)

Challenge

- What cool pictures can you make using the available runes and functions?
- Refer to CS1101S AY2013/2014 Rune Contest slides

Technical interviews

- Interview where tech companies test interviewees on how “zai” they are. E.g. Google, Microsoft, etc.

- Quite interesting sometimes. Like brainteasers.

- Usually can learn some interesting stuff from the questions

- Now let’s look at some actual technical interview questions

Swapping without temp

- Recall your swapping code

```
swap(a,b) {
    var temp = a;
    a = b;
    b = temp;
}
```

- How to swap without creating/using a temporary variable?

Swapping without temp

- Solution #1 (Addition and subtraction)

```
swap(a,b) {
    a = a+b; // a now holds a+b
    b = a-b; // b now holds a
    a = a-b; // a now holds b
}
```

Swapping without temp

- Solution #2 (XOR)
- What is XOR?
  - E**x**clusive-**OR**
  - 0 XOR 1 = 1 XOR 0 = 1
  - 0 XOR 0 = 1 XOR 1 = 0

Swapping without temp

- Solution #2 (XOR)

```
swap(a,b) {
    a = a XOR b; // a now holds a XOR b
    b = a XOR b; // b now holds a
    a = a XOR b; // a now holds b
}
```

- Same idea, replace +, - with XOR

Quicksort

- “Write quicksort” <u>on a whiteboard</u> (cannot test)
- Actual interview question from Microsoft
  - One of my professor used to work in Microsoft
  - This was one often common interview questions
- What’s this “quicksort”?
  - A sorting algorithm
    (not basic, but it’s quick. Can guess from name right?)

Find median in 2 sorted arrays

- Recall binary search
  - Given sorted array is sorted, find element X
- Median (vs. Mean vs. Mode) ← 3 types of “average”
  - “Center” element. Left side size = Right side size
- Now:
  - Given 2 sorted arrays find middle element

Find median in 2 sorted arrays

- Given 2 sorted arrays find middle element of all elements

how do you know what's "slow"?

- Easy (but *slow*) solution
  - Combine both array into new array **newArr**
  - Sort
  - Return **newArr[size/2]**
- Apply binary search simultaneously on both arrays!

Why am I sharing these?

- Simple mathematical properties like XOR are surprisingly powerful
    - Cryptography uses a lot of XORs…
- You are actually learning actual useful stuff here
- Know how to make use and combine things you have learnt (This applies to everything in life!)

Basic Sorting Topics

- Bubble sort
- Insertion sort
- Selection sort
- Merge sort

Vote on Topics

<u>More general stuff</u>

- Advanced sorting
- Data structures
- Algorithm analysis
- Graph algorithms
- Dynamic programming

<u>More specific things:</u>

- Basic cryptography
- Minimax algorithm
- Project Euler
- Computer Organization
- Build a program/game

Suggestions?

Advanced sorting

- Heap sort
- Quick sort
- Counting sort
- Radix sort
- Bucket sort

Heaps

Needs a little data structure

Hash tables

Data structures

- Heaps (implementation in arrays)
- Trees (balanced trees? augmented trees?)
- Hash tables
- Linked lists
- Stack/Queue
- Priority Queues

Algorithm analysis

- Remember how we said “quicksort is quick” and easy approach earlier was “slow”?
- How to measure how fast/good an algorithm is?
- Space complexity, Time complexity
- Big-O notation

Graph algorithms

- Examples you know of:
  Pancake flipping, shortest path algorithm
- Other examples: BFS, DFS, Topological Sort, etc.
- Applications (in Artificial Intelligence):
  A* Search (general form of Dijkstra's)
  Minimax algorithm

Dynamic Programming

- Another class of useful program solving skill
  - Besides recursion/divide-and-conquer
- In fact, one of the most powerful ones…
- But not trivial to understand
- Idea: Similar to recursion but don't repeat computation
- Example: Fibonacci

Basic cryptography

- Shift ciphers
- Affine ciphers
- Block ciphers (?)
- RSA (?)
  - http://en.wikipedia.org/wiki/RSA_(cryptosystem)
- Program your own encoding/decoding code

Good way to show you why programming is useful (no one do these by hand)

Minimax algorithm

- Best way to play a game / decide action
- Used in basic A.I. programs
- Example: Tic-tac-toe

Project Euler

- http://projecteuler.net

About Project Euler

What is Project Euler?

Project Euler is a series of challenging mathematical/computer programming problems that will require more than just mathematical insights to solve. Although mathematics will help you arrive at elegant and efficient methods, the use of a computer and programming skills will be required to solve most problems.

The motivation for starting Project Euler, and its continuation, is to provide a platform for the inquiring mind to delve into unfamiliar areas and learn new concepts in a fun and recreational context.

Who are the problems aimed at?

The intended audience include students for whom the basic curriculum is not feeding their hunger to learn, adults whose background was not primarily mathematics but had an interest in things mathematical, and professionals who want to keep their problem solving and mathematics on the edge.

- We'll work on the questions together one by one

Computer Organisation

- Curious about internal workings of a computer?
- How do computers represent numbers?
- How do computers do calculations?
- What are logic gates?
- Etc etc…

Build a program/game

- Build something (Ever had a cool idea?)
- Learn skills along the way to accomplish goal
- I can suggest topics or you can propose
- Can be group work

Vote on Topics

<u>More general stuff</u>

- Advanced sorting
- Data structures
- Algorithm analysis
- Graph algorithms
- Dynamic programming

<u>More specific things:</u>

- Basic cryptography
- Minimax algorithm
- Project Euler
- Computer Organisation
- Build a program/game

Suggestions?

Computational Thinking

Temasek Junior College

Davin Choo
cxjdavin+CTC@gmail.com

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Vote on Topics

More general stuff

- Advanced sorting
- Data structures
- Algorithm analysis
- Graph algorithms
- Dynamic programming

More specific things:

- Basic cryptography
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- Project Euler
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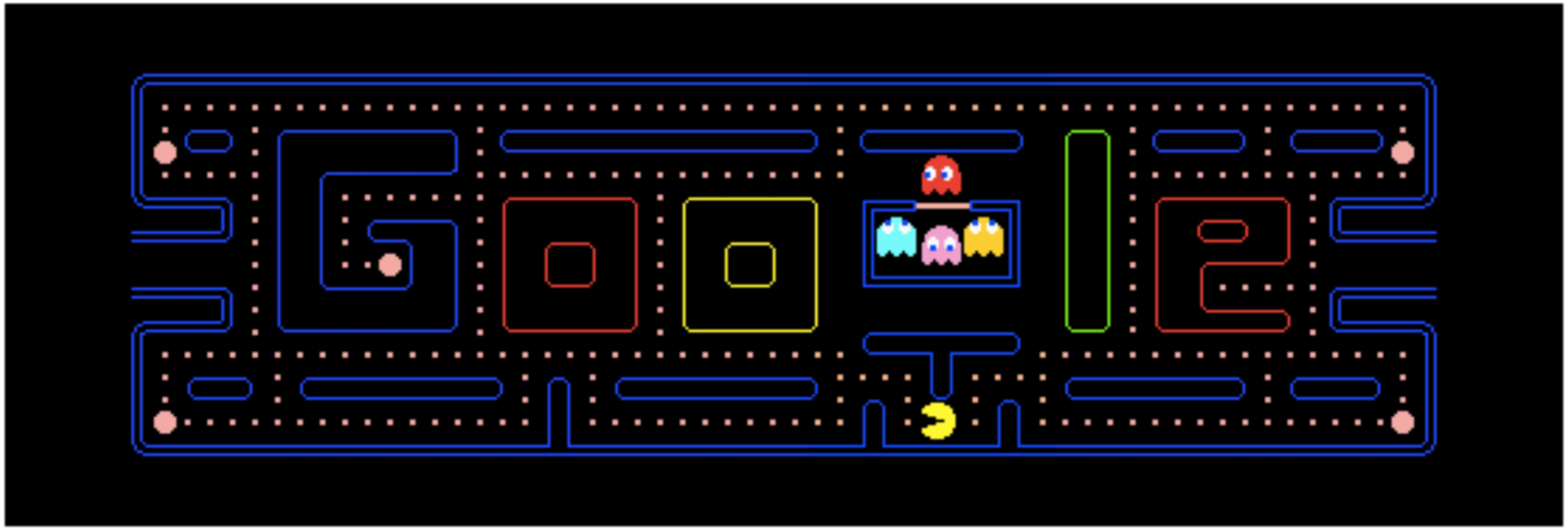
- Build a program/game

4/5 votes!

Suggestions?

Pacman



https://www.google.com/doodles/30th-anniversary-of-pac-man

But first…

Sorts

Sorts

Bubble sort

Insertion sort

Selection sort

Merge sort

Seen this before?

Uniform Group (NPCC) Sizing

https://www.youtube.com/watch?v=gdVPKxQUJKo

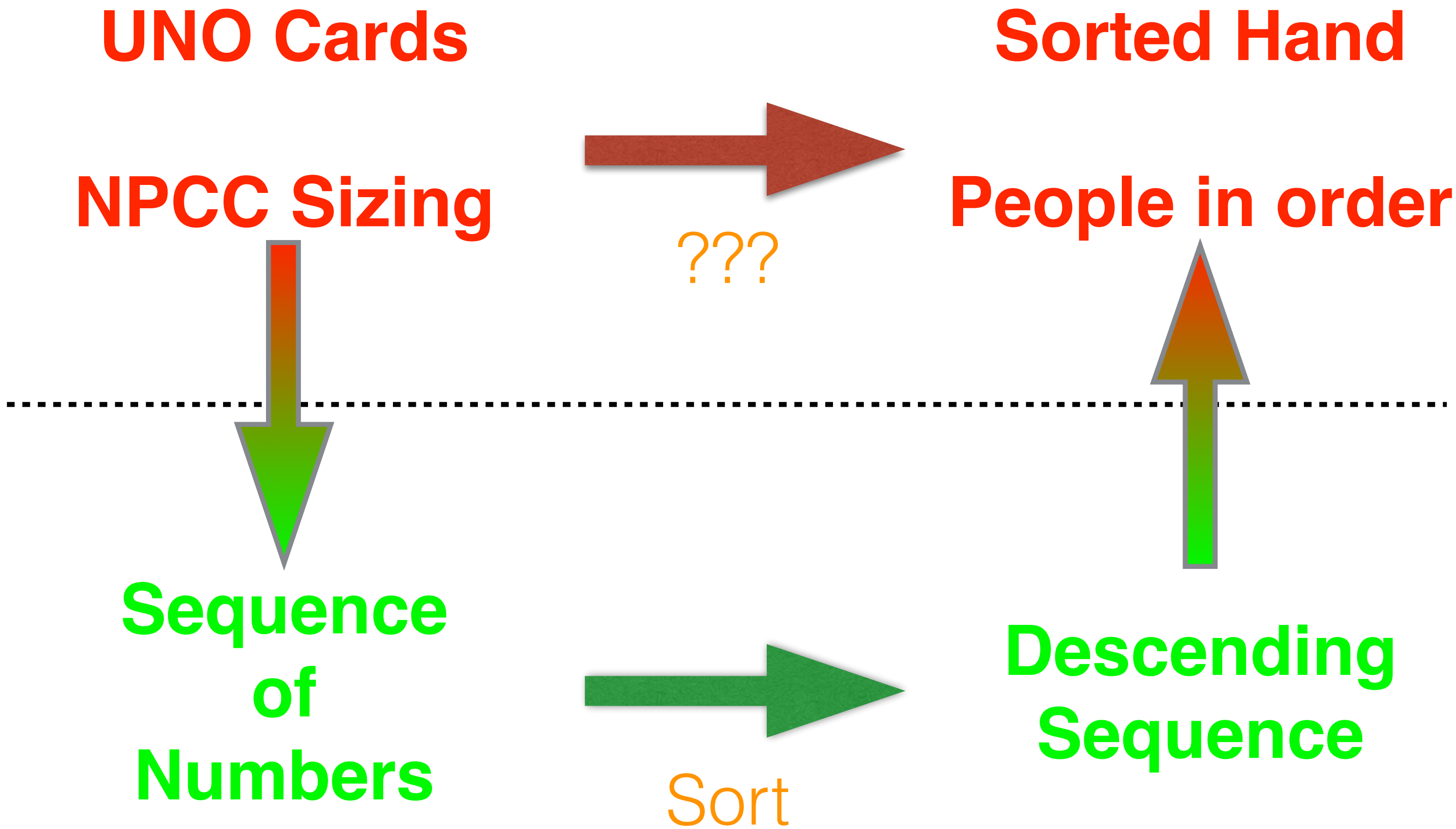
NPCC Sizing

- To make contingent look “nicer”
- How it works
    - Line up in descending order
    - Alternate numbering between 1 and 2
    - “1” step forward; “2” step backwards
    - March and form up

Sorting

- Line up in descending order
- What if we have 10000 people?
- Abstract into a model
    - Input: A sequence of numbers
    - Output: Sequence in descending order

Models


UNO Cards
NPCC Sizing
Sorted Hand
People in order
???
Sequence of Numbers
Descending Sequence
Sort

Hands on

<u>All of you stand up and gather to the front</u>

Arrange in descending height order

Arrange in earliest birthday order

Arrange in alphabetical name order

Hands on

- How many people did you compare with? (Roughly)
- That means ____ comparisons in total…
- Lower # comparisons better (Algorithm analysis)

UNO Cards

Let us use UNO cards as an abstraction/example

Consider [4, 5, 1, 2, 9, 6, 8]

http://img.4plebs.org/boards/tg/image/1368/87/1368871995105.png

Bubble sort

Idea: Iterative! We already know how!

1. Look from left to right
   - If it is larger than the card on it's left, swap
   - Stop when we reach last card
2. If we made a swap, repeat Step 1.

Bubble sort

- Why does it work?
- If already sorted?
  - ___ comparisons
  - ___ swaps
- If reversed order initially?
  - ___ comparisons
  - ___ swaps

Insertion sort

Idea: Iterative!

We already know how!

1. Look from left to right
   - If it is larger than the card on it's left, swap
   - Keep swapping until left card is larger or same
   - Stop when we reach last card

Insertion sort

- Why does it work?
- If already sorted?
  - ___ comparisons
  - ___ swaps
- If reversed order initially?
  - ___ comparisons
  - ___ swaps

Selection sort

We already know how!

Idea: Iterative!

By swapping

1. Look at cards, find maximum
2. Put maximum at left most side
3. Look at the rest of the cards (Repeat 1)

Selection sort

- Why does it work?
- If already sorted?
  - ___ comparisons
  - ___ swaps
- If reversed order initially?
  - ___ comparisons
  - ___ swaps

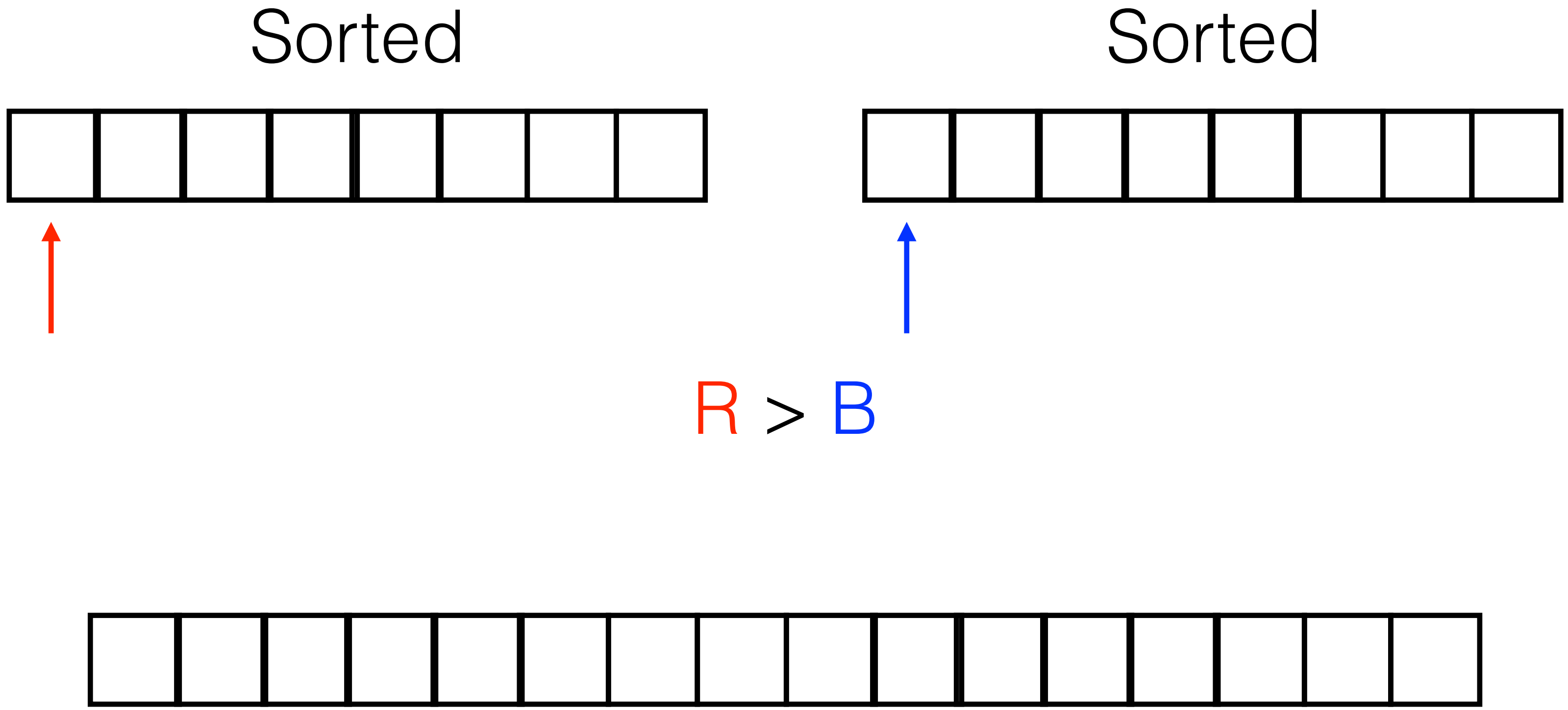
Merge sort

Idea: Recursive!

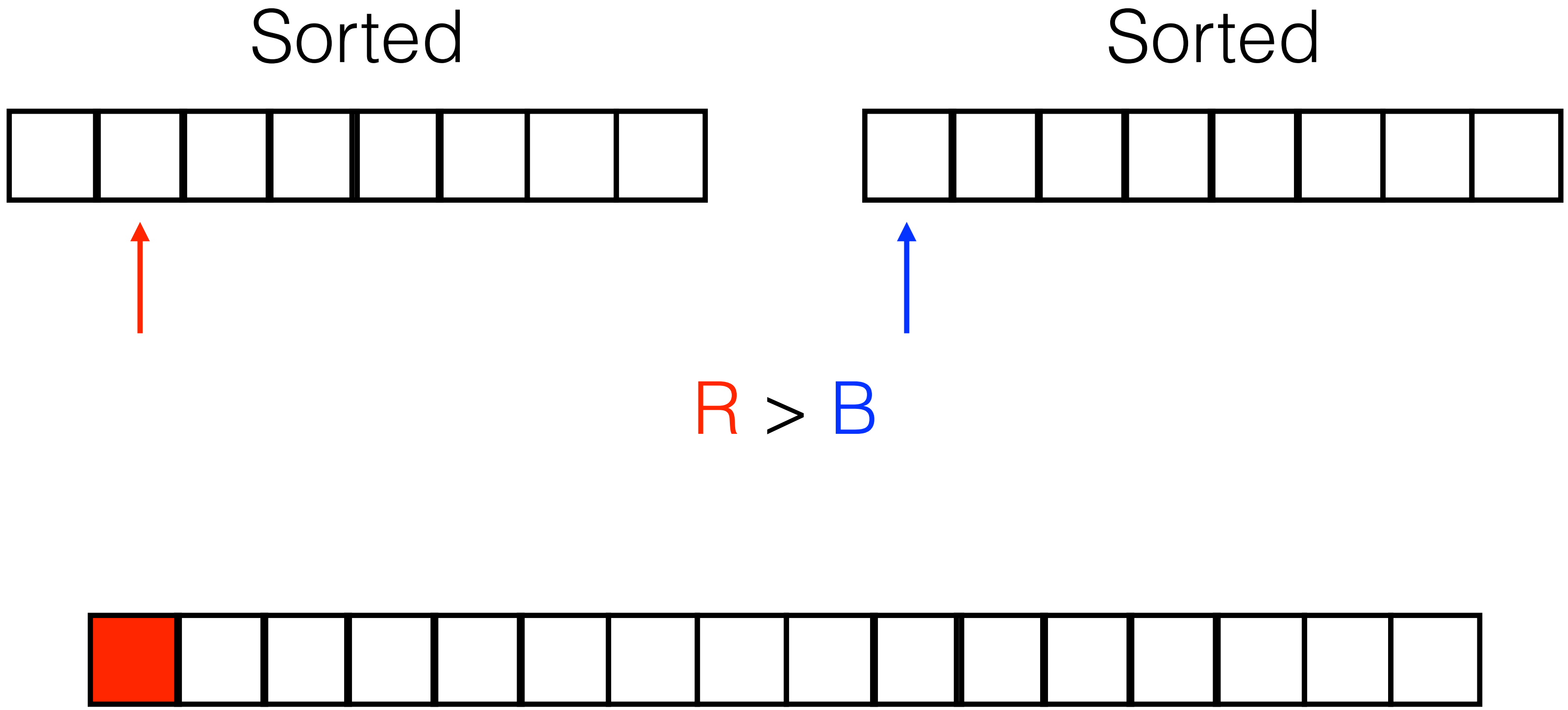
1. Split cards into K portions (usually K=2)
2. Sort each portion ← By using **any** sort
3. Combine sorted portions ("Merge step")

How?

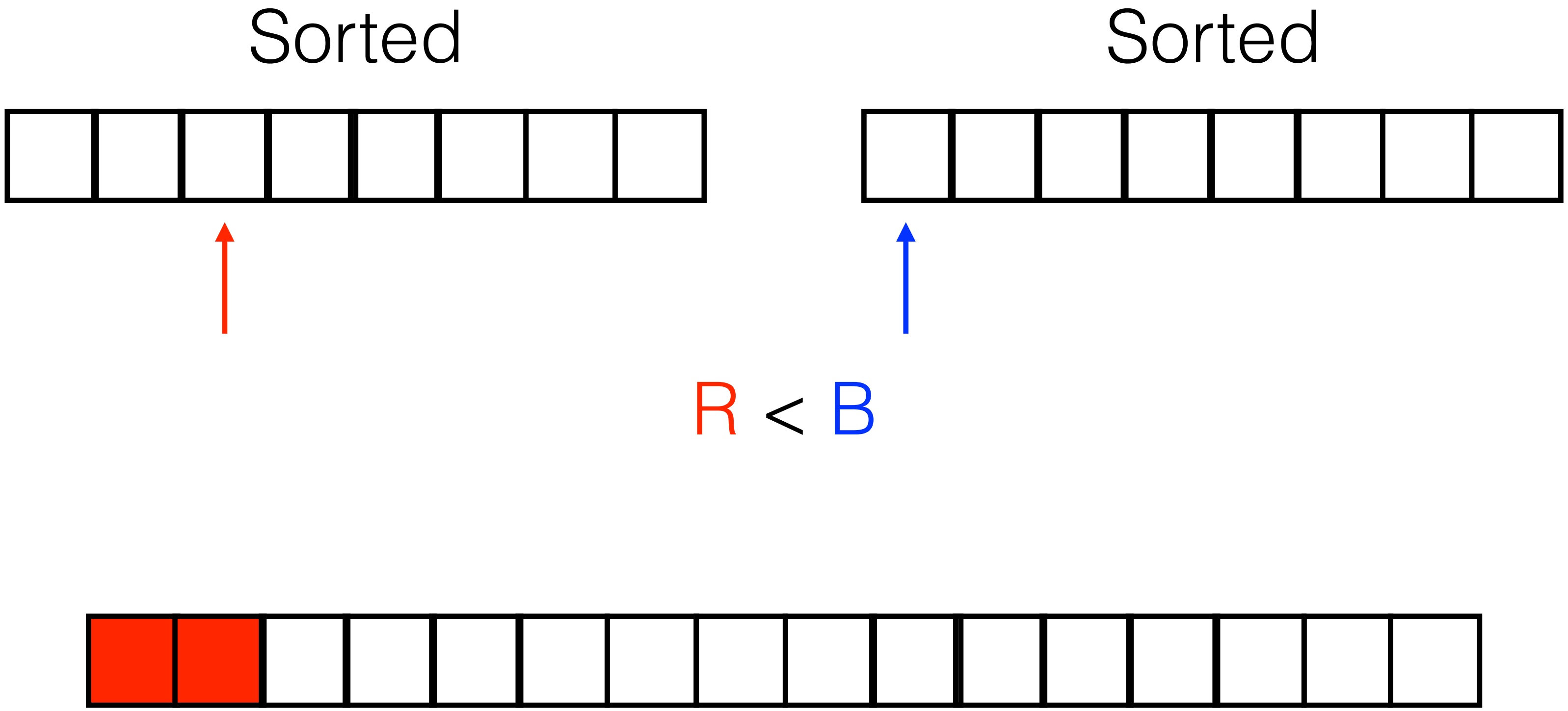
Merge



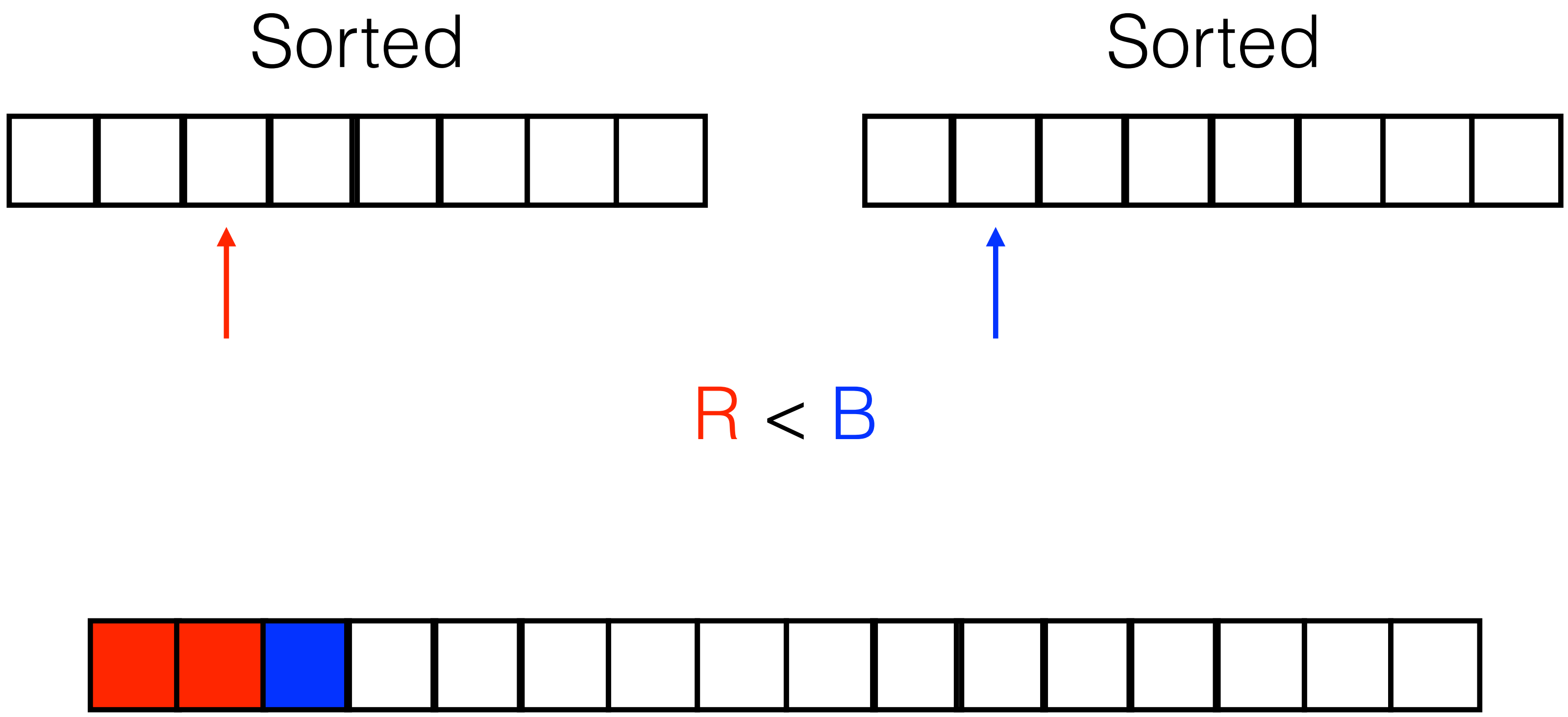
Merge



Merge



Merge



Merge sort

- Why does it work?
- If already sorted?
    - ___ comparisons
    - ___ swaps
- If reversed order initially?
    - ___ comparisons
    - ___ swaps

Loop invariant

- A property that is <u>guaranteed</u> before and after every iteration of a loop
- Example:
  - Terminating conditions in a loop

Loop invariant

- Bubble sort
  - Every time we are done from L to R,
    cards are 1 position closer to correct position
- Insertion sort
  - Left portion of cards always in sorted order
- Selection sort
  - After K steps, K largest cards are in correct place

Parallelism

<u>Idea</u>

- Multi-core / multiple processors
- Split workload and combine results
- Can apply to sorts we learnt so far?

Parallelism

- Bubble sort
  - Check alternate cards at same time
- Insertion sort & Selection sort
  - Can’t. Why?
- Merge sort
  - Perfect! One processor sort 1 portion

Performance

- Algorithmic analysis
  - Worst case performance
  - Best case performance
- In practice…
  - Small N: Insertion sort
  - Large N: Merge sort, until small N, then insertion

Computational Thinking

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Davin Choo
cxjdavin+CTC@gmail.com

What are these?

- HTML5
  - Hyper Text Markup Language
  - Standard markup language used to create web pages
- CSS
  - Cascading Style Sheets
  - Used for describing look and formatting in markup languages
- JS
  - Javascript

Goals for today

- Basic HTML5 syntax
- How to draw using HTML5 <canvas>
- How to capture keyboard inputs
- How to simulate motion
- Some game logic

Basic HTML5

- Tags
- Canvas
- Demo (basic.html)
- Demo (canvas_demo.html)

Events

- Capturing keyboard inputs
- Demo (keycapture.html)

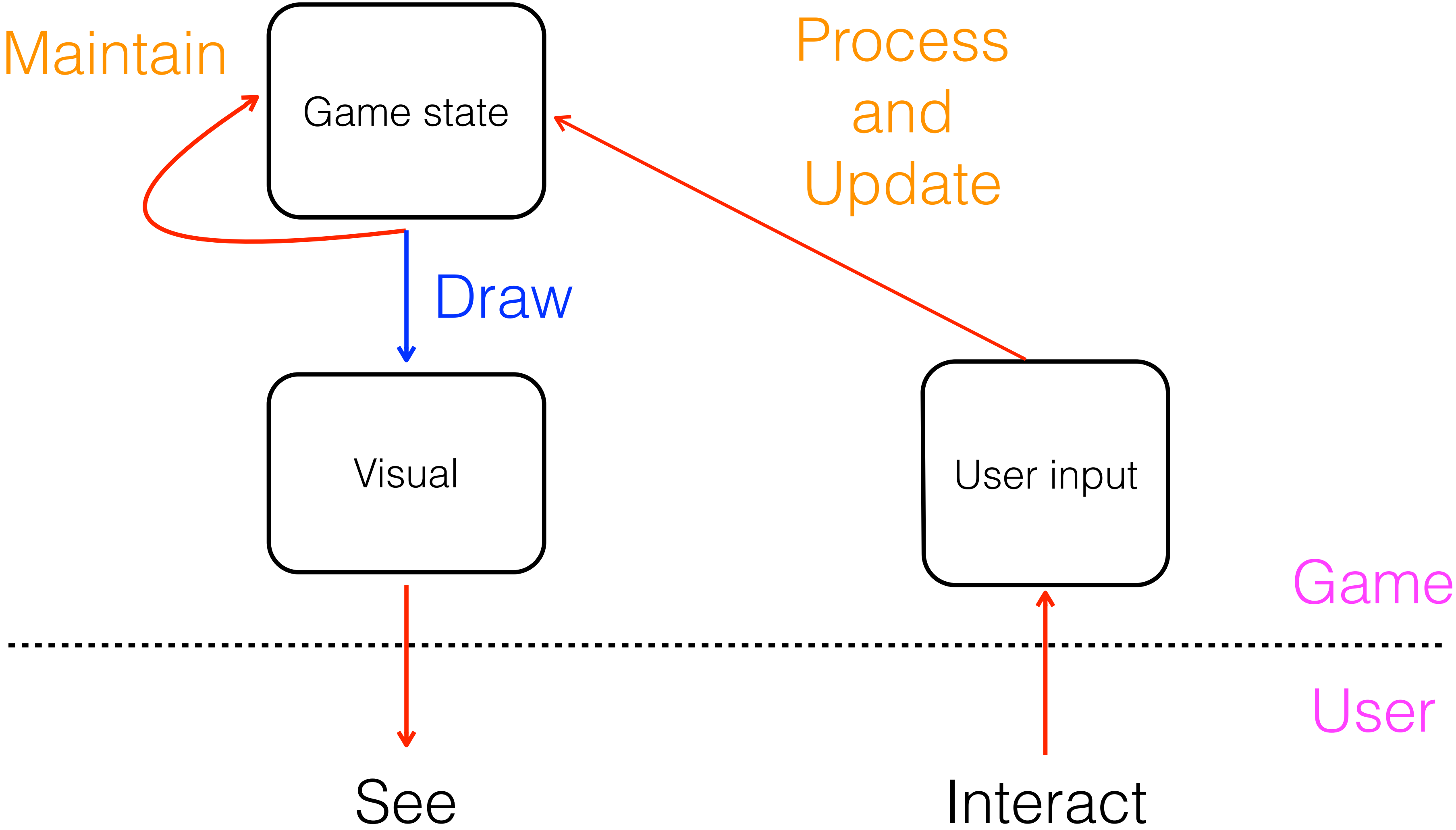
JS Timing Events

- setInterval()
- setTimeout()
- Demo (motion.html)

Other stuff

- A lot of other HTML5 tags
- Alerts
- Nameless functions
- for-loop
- random()

Basic Game Logic



Basic Game Logic

- Maintain
  - Update self-moving things / A.I. motion
- Draw
  - Remember to clear canvas before re-drawing
- Process and update
  - Process keyboard presses / button clicks

2-player catching

- Maintain (Do nothing, until keyboard input detected)
- Draw
  - Clear canvas. Draw player images at player positions.
- Process and update
  - Process keyboard presses
  - Update players’ position accordingly
  - If collide, add point to catcher

2048

- Maintain (Do nothing, until keyboard input detected)
- Draw
  - Clear canvas. Draw cells.
- Process and update
  - Process keyboard presses
  - Update array values (Shift/Combine)
  - Spawn new cell (Either 2 or 4) at random location

Useful links

Tutorials:

http://www.w3schools.com/html/html5_intro.asp

http://www.w3schools.com/html/html5_canvas.asp

http://www.w3schools.com/js/js_timing.asp

Key codes (to capture keyboard input):

http://www.cambiaresearch.com/articles/15/javascript-char-codes-key-codes