Algorithmic Problem Solving

IS 101Y/CMSC 104Y
First Year IT

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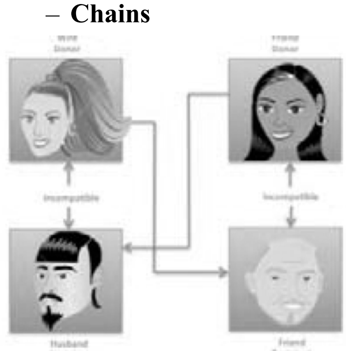
- Questions
- Announcements
- Names

Important Problems

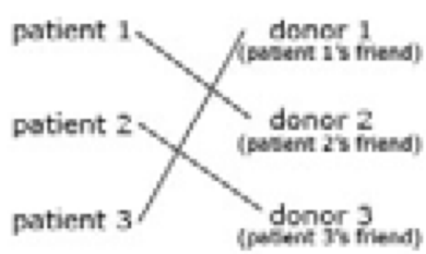
- Health
  - Cure disease, increase health coverage,
- Prosperity
  - End poverty, restore world economy, end world hunger, improve safety and cybersecurity, spread education, create job opportunities, decrease gas prices
- Environment
  - Manage natural resources, reduce pollution, stop global warming
- Scientific/technical discovery
  - Develop hovercars, explore space
- Freedom/Justice
  - Increase equality, stand against oppression, reduce partisanship, establish world peace, fix foreign policy,
- Personal fulfillment
  - Be happy, build good relationships, learn from mistakes, express self, be financially independent, take risks/chances, spread love, improve time management,

A Kidney Story

- Kidney disease affects 50,000 new Americans a year
- Transplants as treatment
  - Pairs
  - Cycles
  - Chains



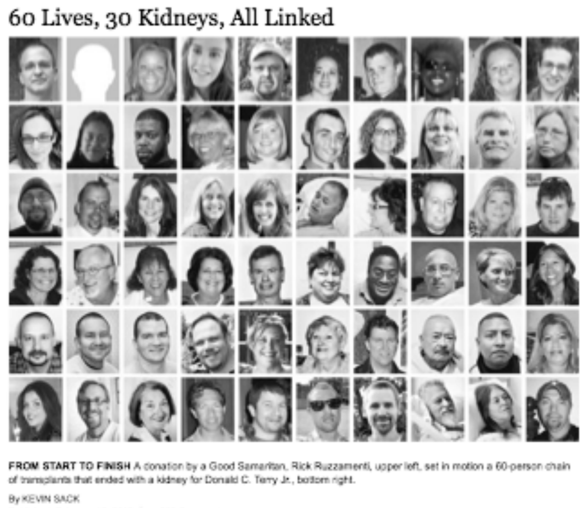
Two cycle



Three cycle

A Big Kidney Story

What about really big chains?



How do you come up with optimal series of swaps?

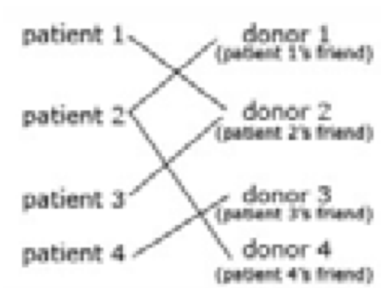
For more info:

NY Times, Feb 9, 2012

– **http://www.nsf.gov/cise/csbytes**

Kidney Exchange

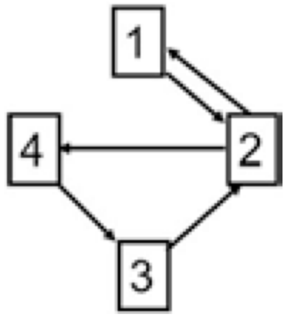
- **Consider the exchange below. A patient is connected to a donor if they are biologically compatible. A donor will only donate a kidney if his or her friend also receives a kidney. What is the optimal matching for this exchange? Why?**



- **What technique did you use to solve this problem? How would your technique scale if there were ten donors and patients? 100? Thousands?**

Alternative Representation

- A graph data structure can capture the important relationships among patients and donors.



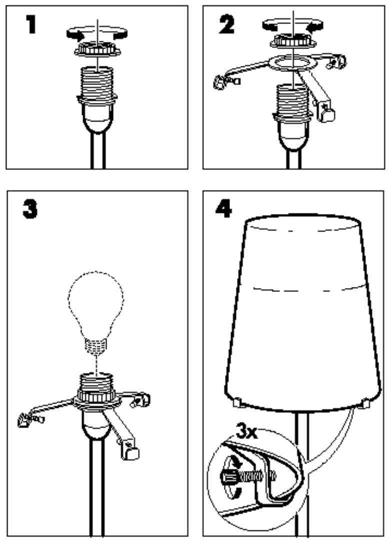
- A legal exchange is one where there is a path following edges that visits each vertex exactly once and returns to the starting vertex (if every node = Hamiltonian cycle, http://nrich.maths.org/2320).
- What is the longest such path in this graph?

Algorithms

- An algorithm is an ordered set of unambiguous steps that describes a process.
- Examples from real life

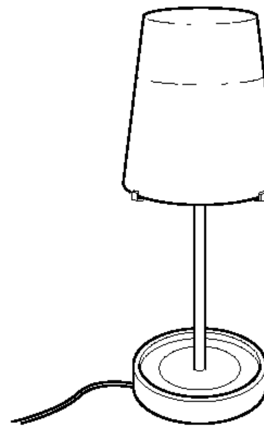
Examples

Let dough rest at least 2 hours, roll dough 1/4 inch thick and cut with a cutter Bake 7 to 10 minutes on a greased cookie sheet. Do not peek! Makes 2 dozen cookies.



BASISK

ENGLISH
FRANÇAIS
ESPAÑOL



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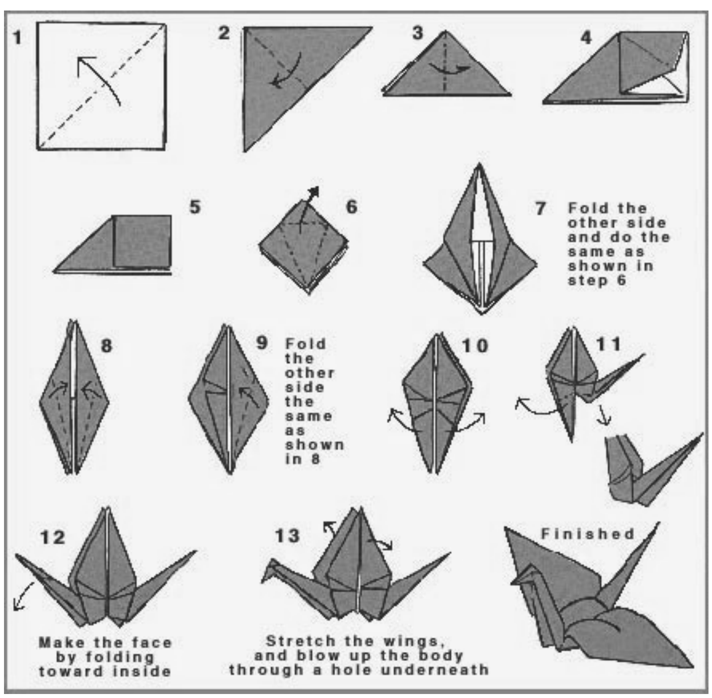

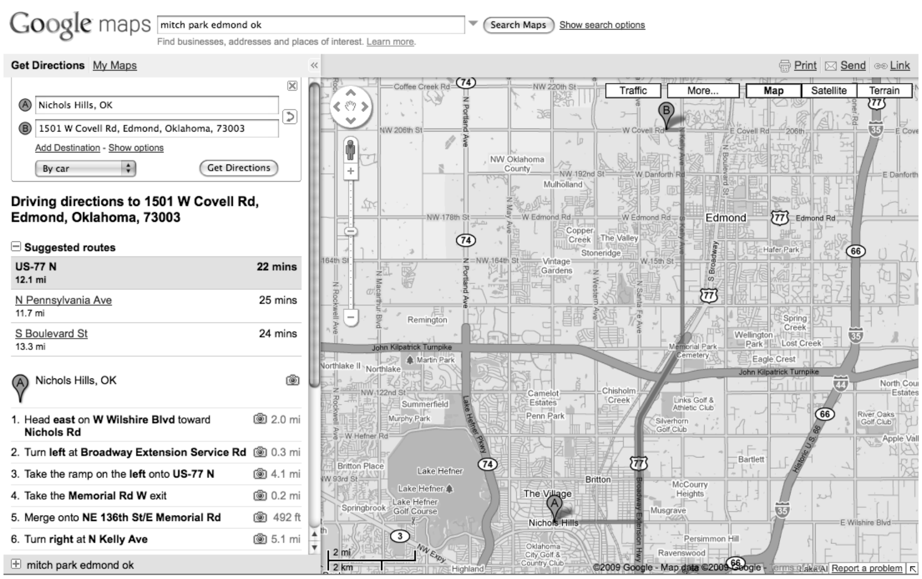
Google maps
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Search Maps
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Link
Nichols Hills, OK
1501 W Covell Rd, Edmond, Oklahoma, 73003
Add Destination - Show options
By car
Get Directions
Driving directions to 1501 W Covell Rd, Edmond, Oklahoma, 73003
Suggested routes
US-77 N 22 mins
12.1 mi
N Pennsylvania Ave 25 mins
11.7 mi
S Boulevard St 24 mins
13.3 mi
Nichols Hills, OK
1. Head east on W Wilshire Blvd toward Nichols Rd 2.0 mi
2. Turn left at Broadway Extension Service Rd 0.3 mi
3. Take the ramp on the left onto US-77 N 4.1 mi
4. Take the Memorial Rd W exit 0.2 mi
5. Merge onto NE 136th St/E Memorial Rd 492 ft
6. Turn right at N Kelly Ave 5.1 mi
mitch park edmond ok
Traffic
More...
Map
Satellite
Terrain
Edmond
John Kilpatrick Turnpike
Lake Hefner
The Village
Nichols Hills
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Poco moto
a tempo
dim. and rit.
legato
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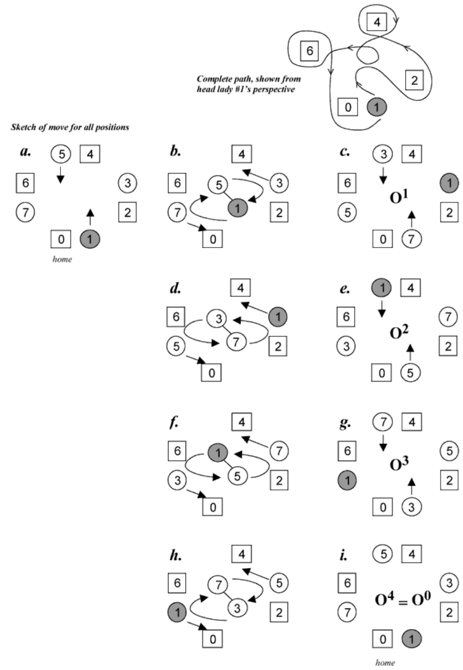
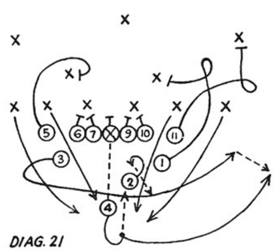
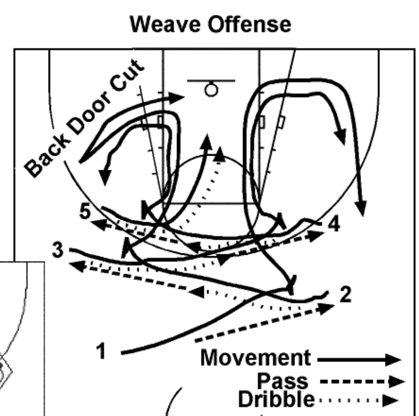


Complete path, shown from head lady #1's perspective
Sketch of move for all positions
a.
home
b.
c.
d.
e.
f.
g.
h.
i.
home



DIAG. 21



Weave Offense
Back Door Cut
Movement
Pass
Dribble

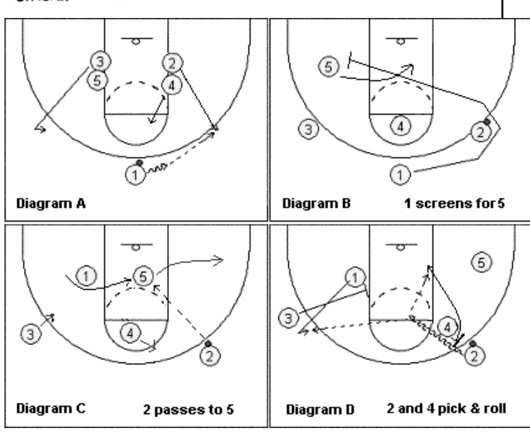


Diagram A
Diagram B
1 screens for 5
Diagram C
2 passes to 5
Diagram D
2 and 4 pick & roll

Friendship

- <u>Friendship Algorithm</u>

Birthdays

- In your group, sort members by increasing order of birthday.

- <u>Sorting algorithms</u>

Whipped Butter Frosting

7 1/2 T all purpose flour

1 1/2 C milk

1 1/2 C butter

1 1/2 C granulated sugar

3/8 t salt

3 t vanilla

Blend flour and milk until smooth. Cook over medium heat until very thick. Stir constantly. Cool. Cream butter at medium speed. Add sugar gradually, 1/4 C at a time. Add milk mixture. Beat until smooth and fluffy. Add salt and vanilla. Beat well.

Whipped Butter Frosting: Revisited

7 1/2 T all purpose flour

1 1/2 C milk

1 1/2 C butter

1 1/2 C granulated sugar

3/8 t salt

3 t vanilla

Blend flour and milk until smooth. Cook over medium heat until very thick. Stir constantly. Cool. Cream butter at medium speed. Add sugar gradually, 1/4 C at a time. Add milk mixture. Beat until smooth and fluffy. Add salt and vanilla. Beat well.

Pseudocode

- Specialized language for describing algorithms
  - General syntax and semantics
  - Not specific to a particular computer language
- Some syntax

  <THING> - any item that is a THING

  { … } - stuff between braces grouped

Pseudocode Primitives

- Procedures and functions

```
procedure <NAME> (<VAR>,  …) { … }
function <NAME> (<VAR>, …) { … return (<EXPR>);}
```

- Assignments and printing

```
<VAR> = <EXPR>          - assignment
print <EXPR>, …
```

- Mathematical Expressions <EXPR>

```
<VAR>                   –  variable value
<EXPR> + <EXPR>         –  result of operation
"<any string>"          –  string
<LIST>[<I>]             –  the Ith item in a list
```

- Logical Conditions <COND>

```
<EXPR1> = = <EXPR2>   – test for equality
<EXPR1> < <EXPR2>     – test for inequality
not <COND>            – test for state
```

More Pseudocode Primitives

- **Conditional logic**

```
if <CONDITION> then { … }
if <CONDITION> then { … } else { … }
```

- **Loops**

```
for <ITEM> in <LIST> do  { … }
for <I> from <MIN> to <MAX> do { … }
while <CONDITION> do { … }
do { … } until <CONDITION>
```

Example: Counting

```
// Print the numbers from 1 to N
procedure PrintNumbers (N) {
  for i from 1 to N {
      print (i)
  }
}
```

Example: Order

- Given the following sentences:
  1. I don’t want pizza again for a long time.
  2. I ate ten pieces of pizza.
  3. Later that night, I got sick.
  4. I felt very full.
- Which of the following orders is correct?
  A) 1, 3, 4, 2
  B) 4, 3, 2, 1
  C) 2, 3, 1, 4
  D) 3, 1, 4, 2
  E) 2, 4, 3, 1
- Concepts: state, search space

Exercise: Guessing

- With team, write pseudocode for guessing a number between 1 and 100. Be prepared why your approach the best way to solve the problem.

Example: Multiplication

How would you multiply two numbers, using only the addition operator?

Concepts: iterations, efficiency

Exercise: Socks

- **With team, write pseudocode for sorting a pile of socks. Be prepared why your approach the best way to solve the problem.**

Algorithms are used to express solutions to computational problems.

- An algorithm is a precise sequence of instructions for a process that can be executed by a computer.
  - Sequencing, selection, iteration, and recursion are building blocks.
  - Different algorithms can be developed to solve the same problem.
- Algorithms are expressed and implemented using languages.
  - natural language, pseudo-code, and visual and textual languages.
  - better suited for expressing different algorithms.
  - can affect clarity or readability, but not whether solution exists.
- Algorithms can solve many, but not all, problems.
  - Many problems can be solved in a reasonable time.
  - Some need heuristic approaches to solve them in a reasonable time.
  - Some problems cannot be solved using any algorithm.
- Algorithms are evaluated analytically and empirically.
  - using many criteria (e.g., efficiency, correctness, and clarity).
  - algorithms for the same problem can have different efficiencies.