LambdaConf, 7 May 2024

Generic Glyphs Different Domains

Josh David

Dyalog

Glyphs

Glyphs

Arithmetic	+ − × ÷ |
Comparisons	< ≤ = ≠ ≥ >
Set Operations	∩ ∪ ~ ∈
Logic	∧ ∨ ⊼ ⊽ ~

Symbols

Play three notes with frequencies of 130.81, 155.56, and 196 Hertz

TwoSum

```
import java.util.HashMap;
import java.util.Map;
class Solution {
    public int[] twoSum(int[] nums, int target) {
        Map<Integer, Integer> numToIndex = new HashMap<>();
        for (int i = 0; i < nums.length; i++) {
            if (numToIndex.containsKey(target - nums[i])) {
                return new int[] {numToIndex.get(target - nums[i]), i};
            }
            numToIndex.put(nums[i], i);
        }
        return new int[] {};
    }
}
```


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```


TwoSum

```
import java.util.HashMap;
import java.util.Map;
class Solution LEFTBRACE
   public int LEFTBRACKET RIGHTBRACKET twoSum LEFTPARANTHESIS int LEFTBRACE RIGHTBRACE nums, int target
RIGHTPARANTEHSIS LEFTBRACKET
      Map LESSTHAN Integer, Integer GREATERTHAN numToIndex EQUALS new HashMap LESSTHAN GREATERTHAN
LEFTPARANTHESIS RIGHTPARANTHESIS;
      for LEFTPARANTHESIS int i EQUALS 0; i LESSTHAN nums.length; i PLUS PLUS RIGHTPARANTHESIS LEFTBRACE
         if LEFTPARANTHESIS numToIndex.containsKey LEFTPARANTHESIS target MINUS nums LEFTBRACKET I
RIGHTBRACKET RIGHTPARANTHESIS RIGHTPARANTHESIS LEFTBRACE
            return new intLEFTBRACKET RIGHTBRACKET LEFTBRACE numToIndex.get LEFTPARANTHESIS target MINUS
nums LEFTBRACKET i RIGHTBRACKET RIGHTPARANTHESIS, i RIGHTBRACE;
         RIGHTBRACE
         numToIndex.put LEFTPARANTHESIS nums LEFTBRACKET i RIGHTBRACKET, i RIGHTPARANTHESIS;
      }
      return new int LEFTBRACKET RIGHT BACKET LEFTBRACE RIGHTBRACE;
   }
}
```


Notation: Math vs APL

$a\ b$	`a×b`
$\frac{x}{y}$	`x÷y`
e^x	`*x`
$\sqrt[2]{x}$	`x*÷2`
$\log_b a$	`b⍟a`
$f\ g\ x$	`f g x`
$\sum_{n=1}^{100} 2n$	`+/2×⍳100`
$\prod_{i=1}^{100} 2n$	`×/2×⍳100`

Generic Glyphs, Different Domains

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Generic Glyphs, Different Domains

```
      ϕ 1 2 3
3 2 1
      ϕ 'colorado estes park'
krap setse odaroloc
```

```
      ϕ ι3

3 2 1
```

Generic Glyphs, Different Domains

```
      m
1 2 3
4 5 6
```

```
m ← 2 3 ⍴ ⍳ 6
```


```
      ⌽ m
3 2 1
6 5 4
```

```
m ← 2 3 ⍴ ⍳ 6
```


```
      ⍉ m
4 5 6
1 2 3
```

```
m ← 2 3 ⍴ ⍳ 6
```


Polymorphism

- Rank
- Type
- Domain

Evolution via Industrial use

> We believe that the design of APL was also affected in important respects by a number of procedures and circumstances. Firstly, from its inception APL has been developed by *using* it in a succession of areas. This emphasis on application clearly favors practicality and simplicity. The treatment of many different areas fostered generalization ...
>
> — Falkoff and Iverson, *The Design of APL*, 1973

Matrix Product

3 investors at 4 locations over 5 years

	G	B	E	A
Investor 1	.50	.10	.20	.30
Investor 2	.20	.60	.40	.30
Investor 3	.30	.30	.40	.40

% Invested

	Y1	Y2	Y3	Y4	Y5
Greece	120	100	40	20	0
Brazil	200	150	100	120	200
Egypt	50	120	220	350	600
Argentina	0	80	100	110	120

$ MM

+ . ×

90	113	104	125	176
164	182	186	249	396
116	155	170	226	348

Generic Glyphs, Different Domains

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60
20 +
+
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Generic Glyphs, Different Domains

Quantum Computing

Creating and manipulating qubits

```
a ← q0
a
↓1
 0
```

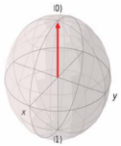
Squared root of the probability of qubit being in ground state

```
b ← q1
b
↓0
 1
```

Squared root of the probability of qubit being in excited state

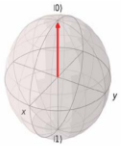
X

```
X
↓0 1
 1 0
```



H

```
H
↓0.7071067812  0.7071067812
 0.7071067812 ¯0.7071067812
```

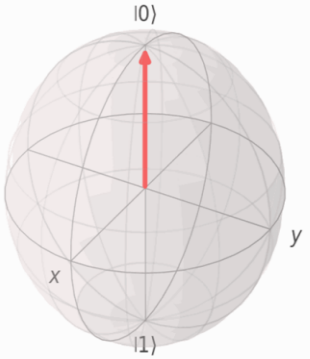


Creating and manipulating qubits

```
H +.× a
↓0.7071067812
 0.7071067812
```

```
H +.× b
↓ 0.7071067812
 ¯0.7071067812
```

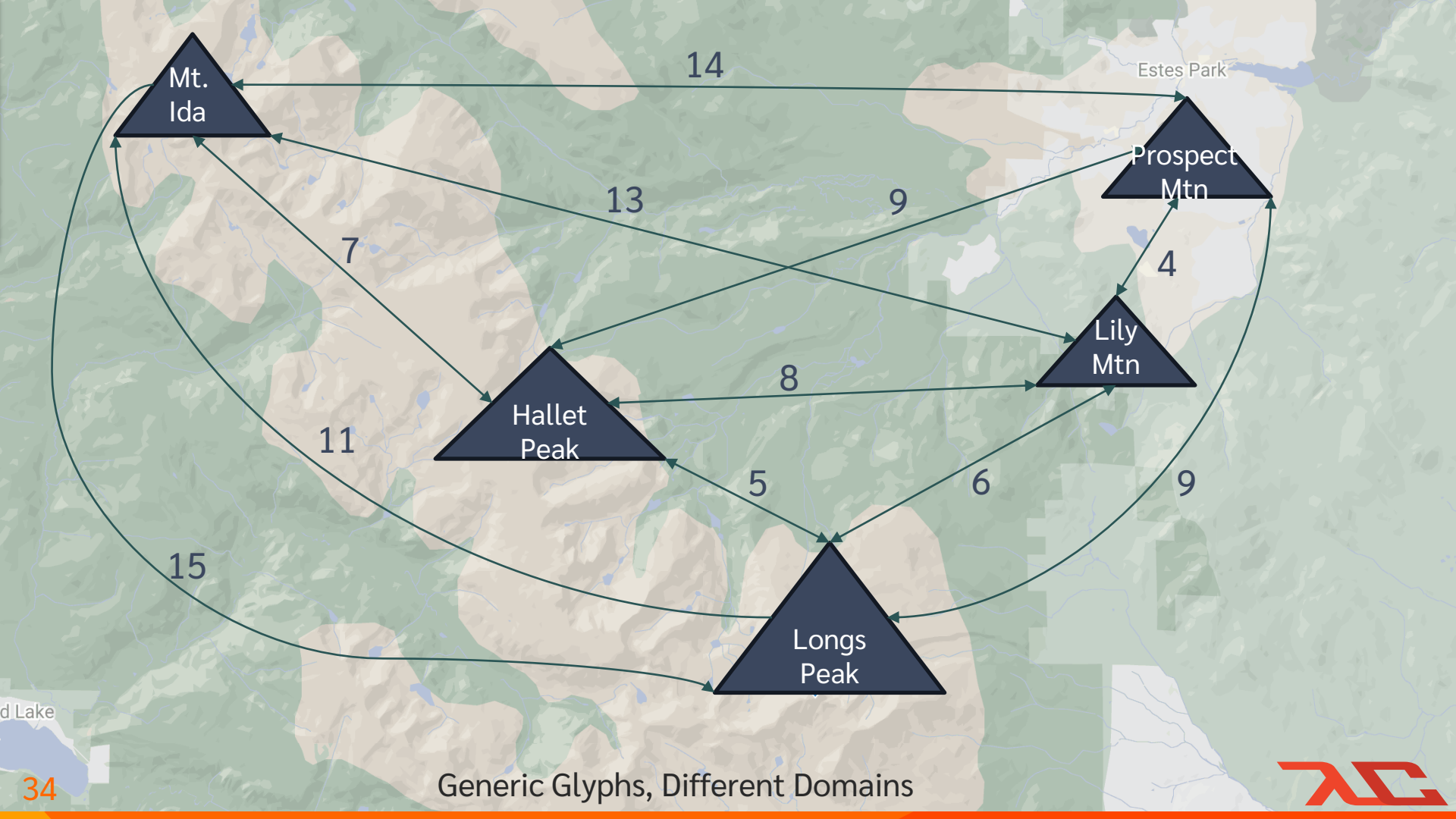
Notice the difference in sign. This indicates a difference in phase of the qubit not in the magnitude



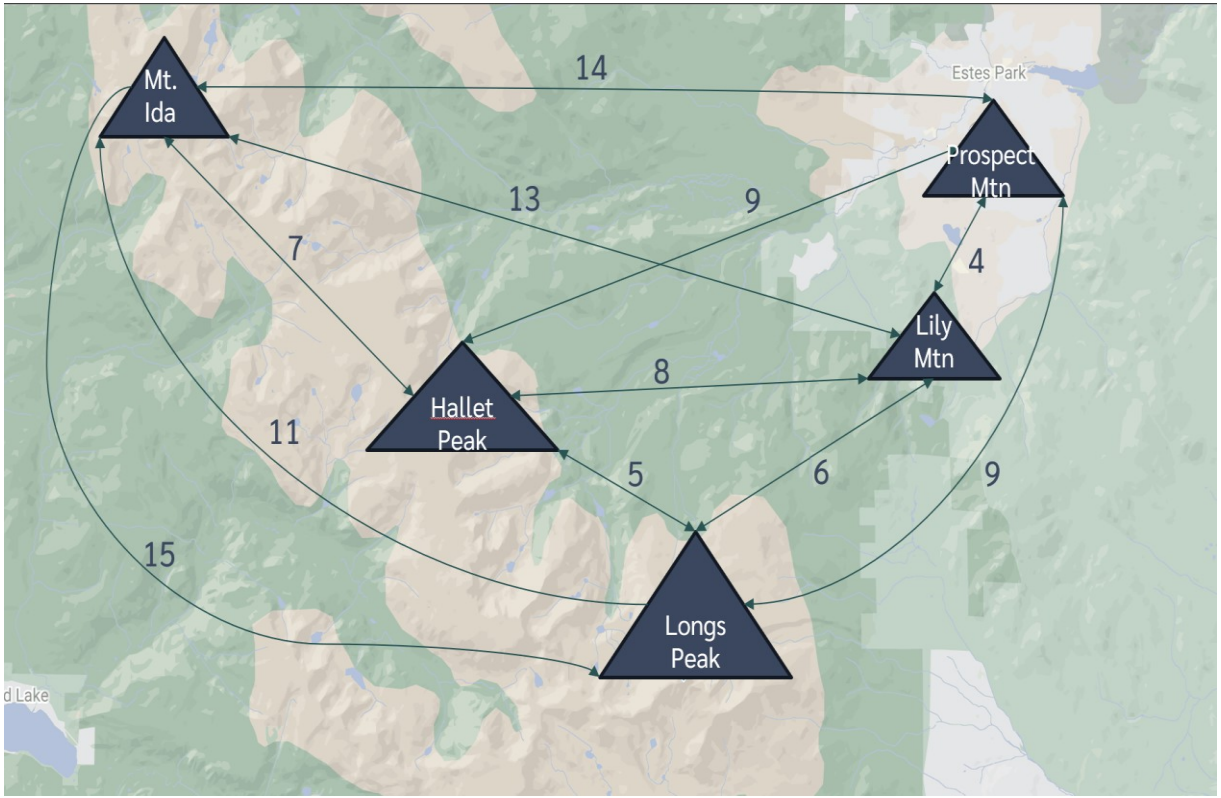
quAPL

“...we demonstrate how features provided by APL, such as native support of complex numbers and matrix operations, naturally capture quan-tum operations while bringing a less cluttered syntax that encodes and encapsulates the linear character of quantum circuit execution...”

https://ieeexplore.ieee.org/document/10313845



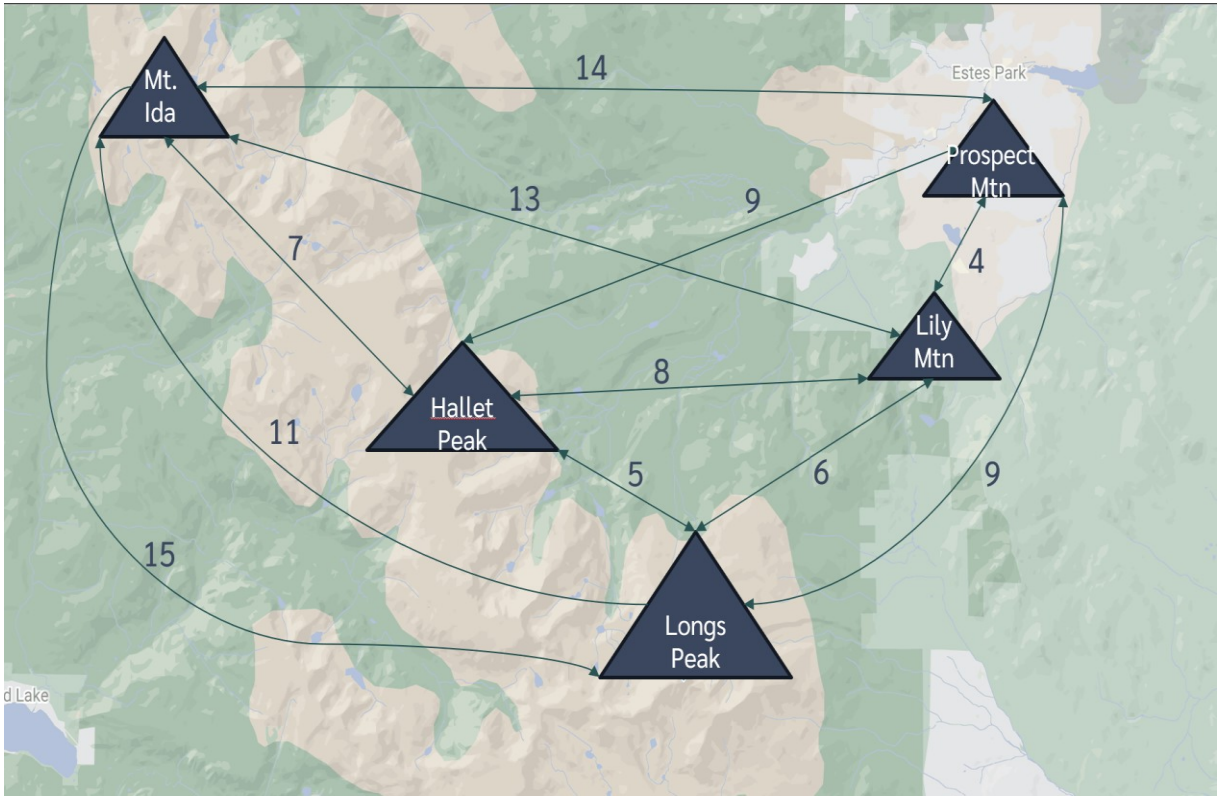
Generic Glyphs, Different Domains



	Ida	Prospect	Hallet	Lily	Longs
Ida	0	14	7	13	15
Prospect	14	0	9	3	9
Hallet	7	9	0	8	5
Lily	13	3	8	0	6
Longs	11	9	5	6	0

```
   ml.+m
 0 14 7 13 12
14  0 9  3  9
 7  9 0  8  5
13  3 8  0  6
11  9 5  6  0
```

Shortest distance through one stop?



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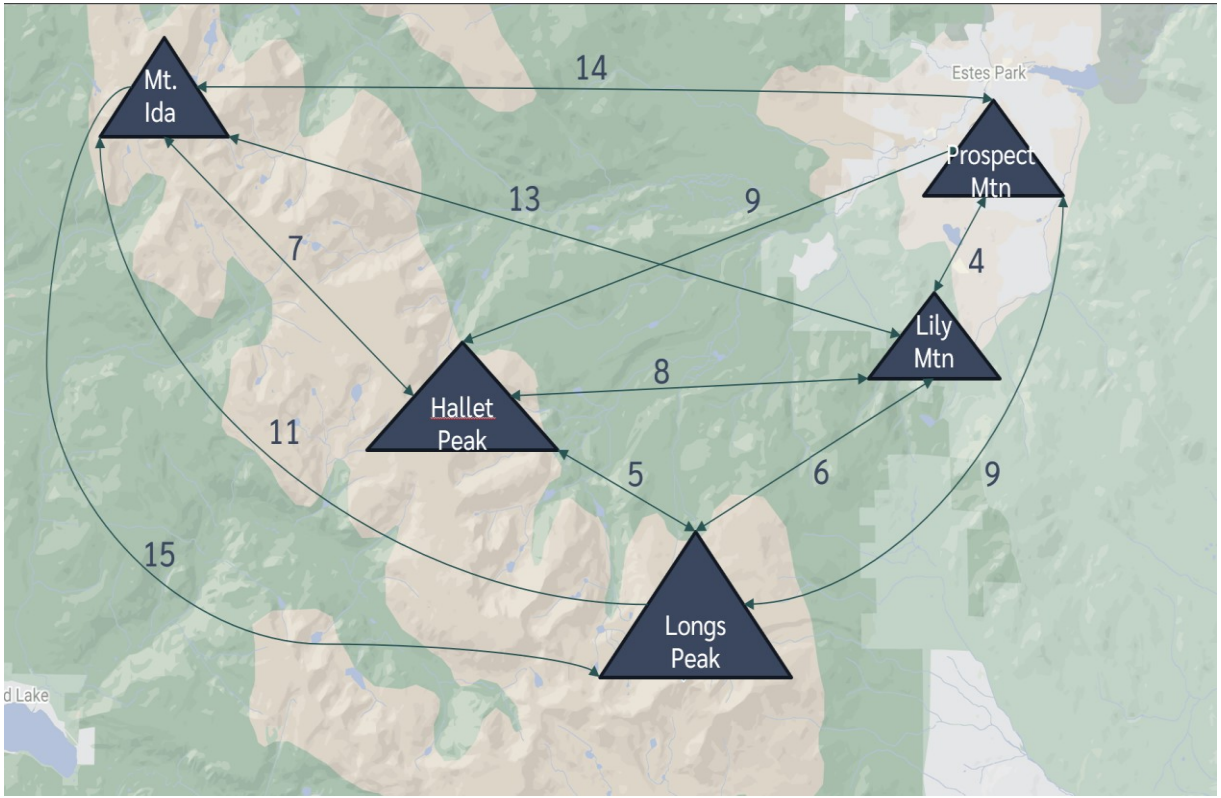

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```
0
14
7
13
15
```

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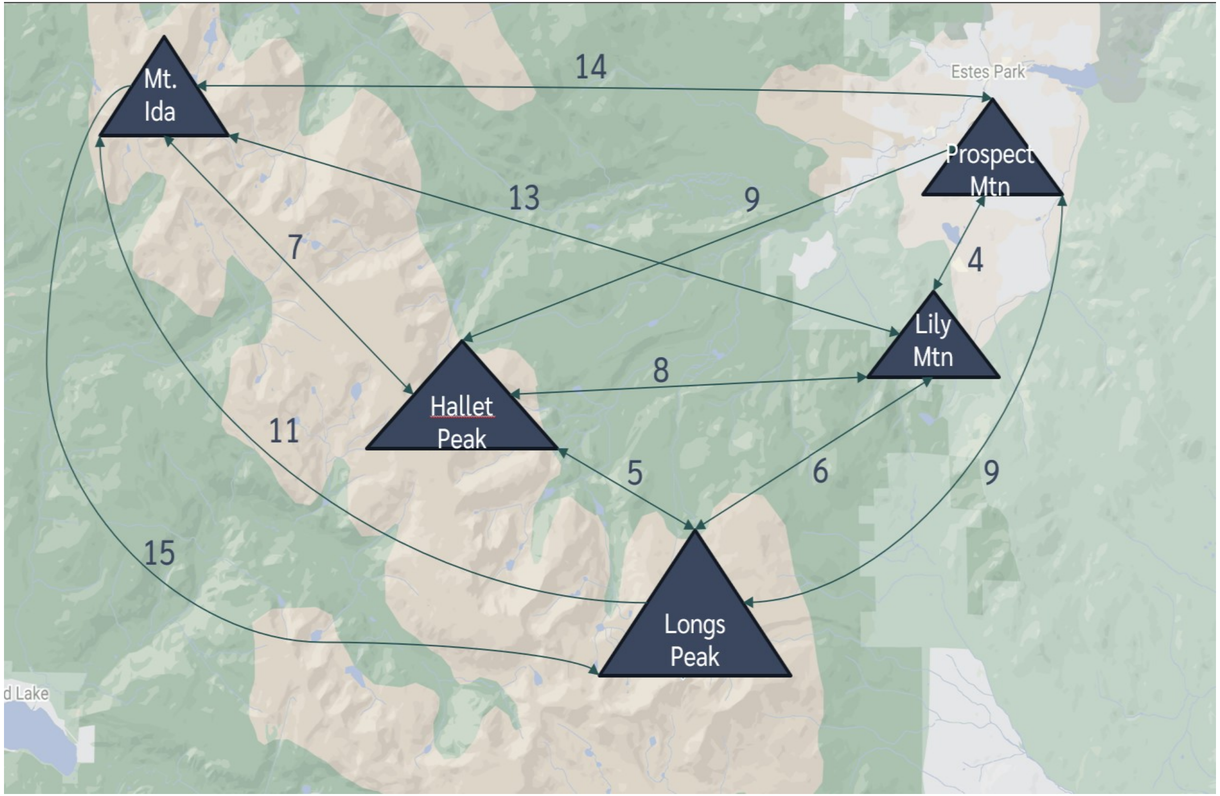

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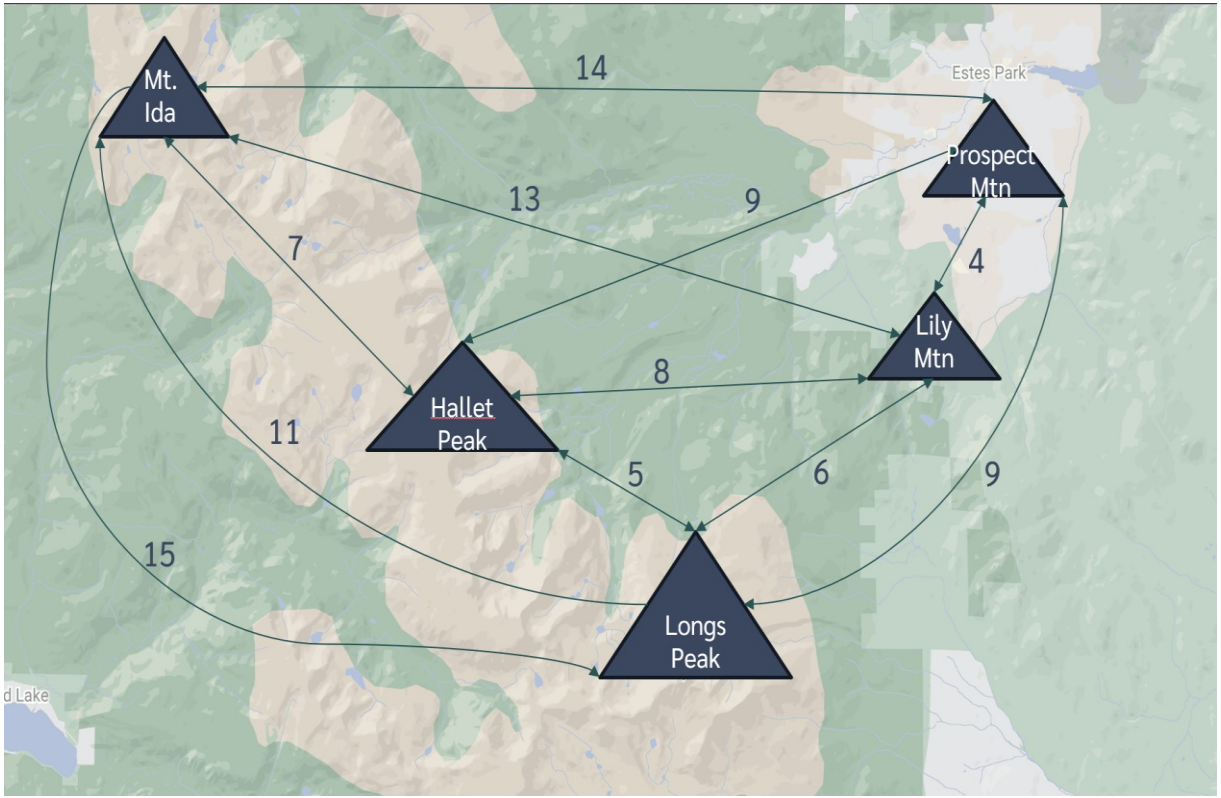
```
m⌊.+m
 0  14  7  13  12
14   0  9   3   9
 7   9  0   8   5
13   3  8   0   6
11   9  5   6   0
```

```
0    15
14   9
7    5
13   6
15   0
```

Shortest distance through one stop?



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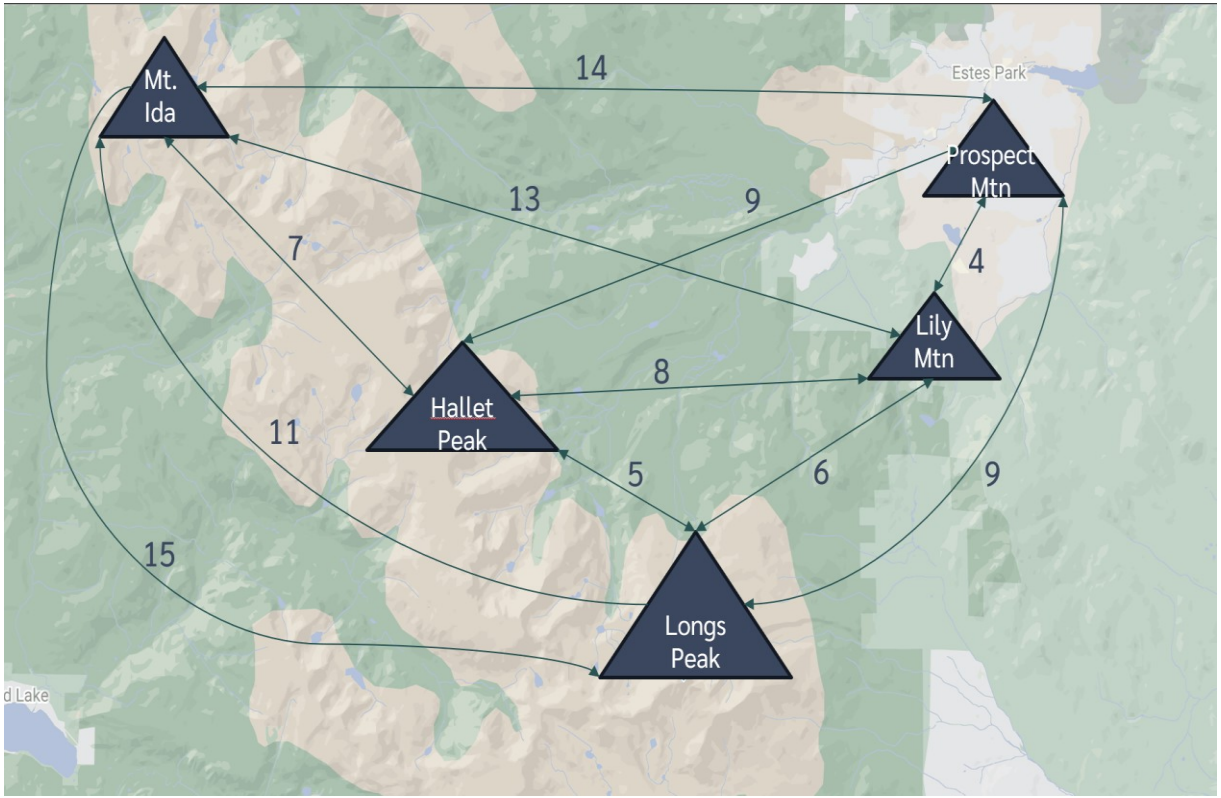
```

15
23
12
19
15

Shortest distance through one stop?



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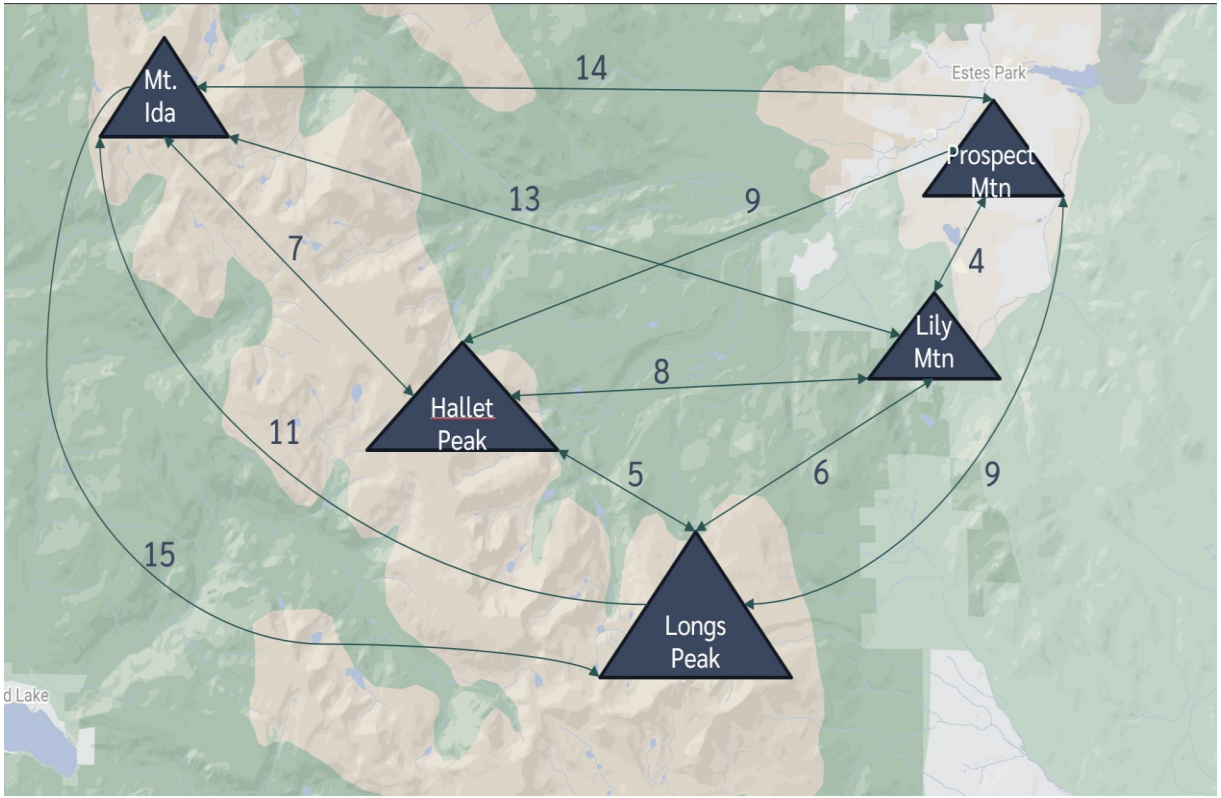

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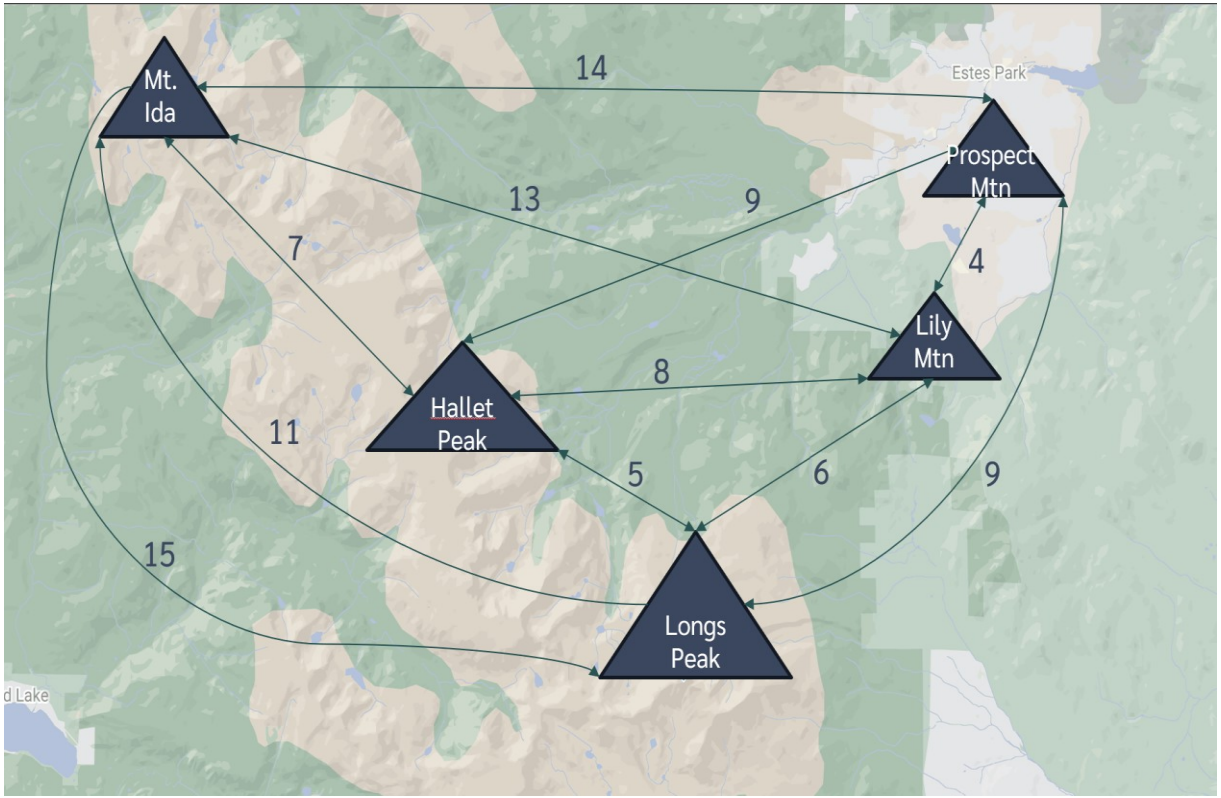
```
  m⌈.+m
28 24 23 21 23
20 28 21 27 29
23 21 18 20 22
17 27 20 26 28
23 25 18 24 26
```

Longest distance through one stop?



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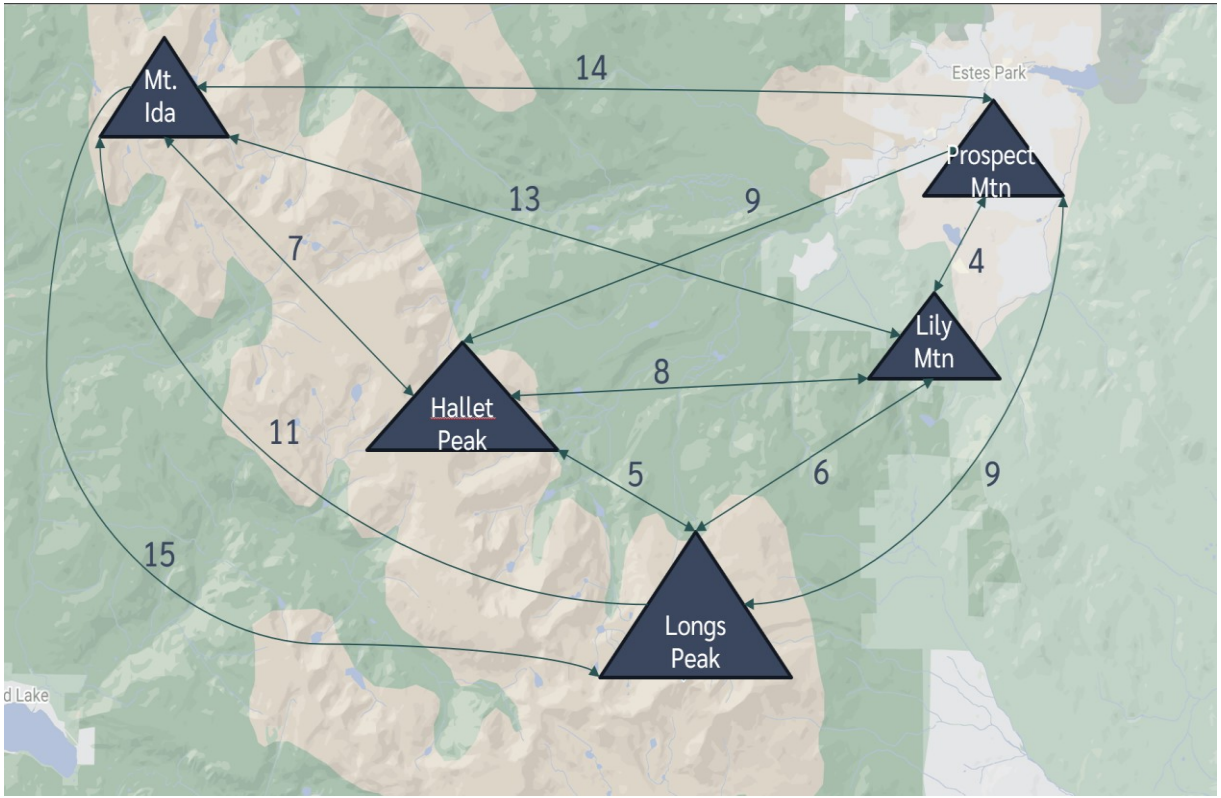
```
      m⌈ .+m⌈ .+m
38 42 35 41 43
42 38 37 35 37
35 37 30 36 38
41 37 36 34 36
39 37 34 36 38
```

Longest distance through two stops?



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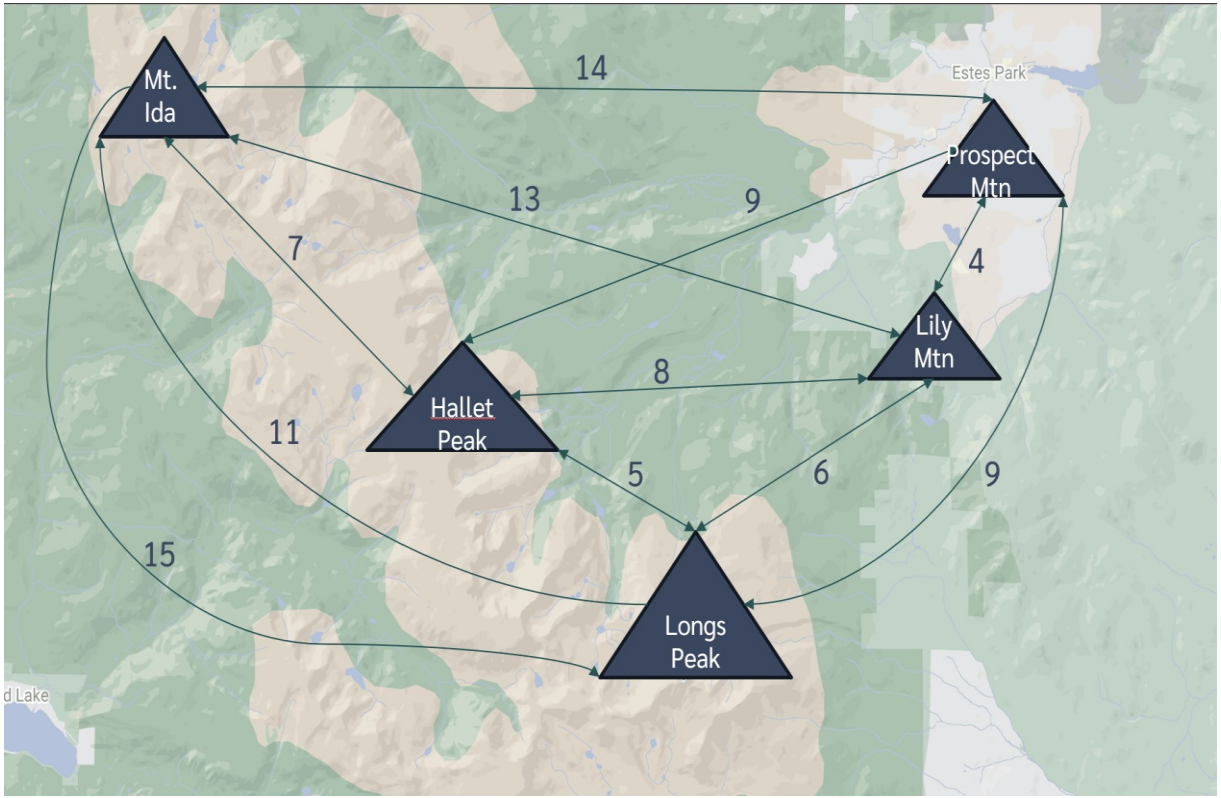
Longs	11	9	5	6	0

```
m⌈.+(⍤2)m
38 42 35 41 43
42 38 37 35 37
35 37 30 36 38
41 37 36 34 36
39 37 34 36 38
```

Longest distance through two stops?



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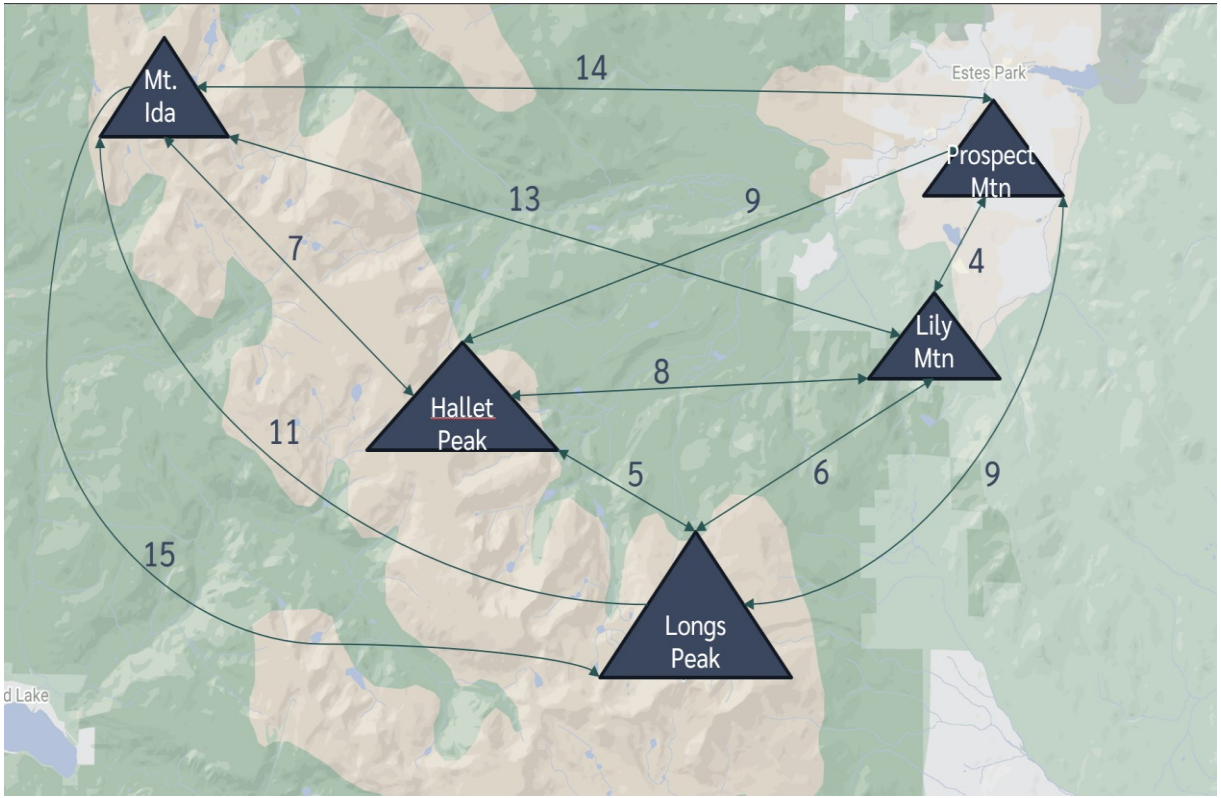
```
m⌈.+(⍤3)m
56 52 51 51 53
52 56 49 55 57
51 49 46 48 50
51 55 48 54 56
51 53 46 52 54
```

Longest distance through three stops?



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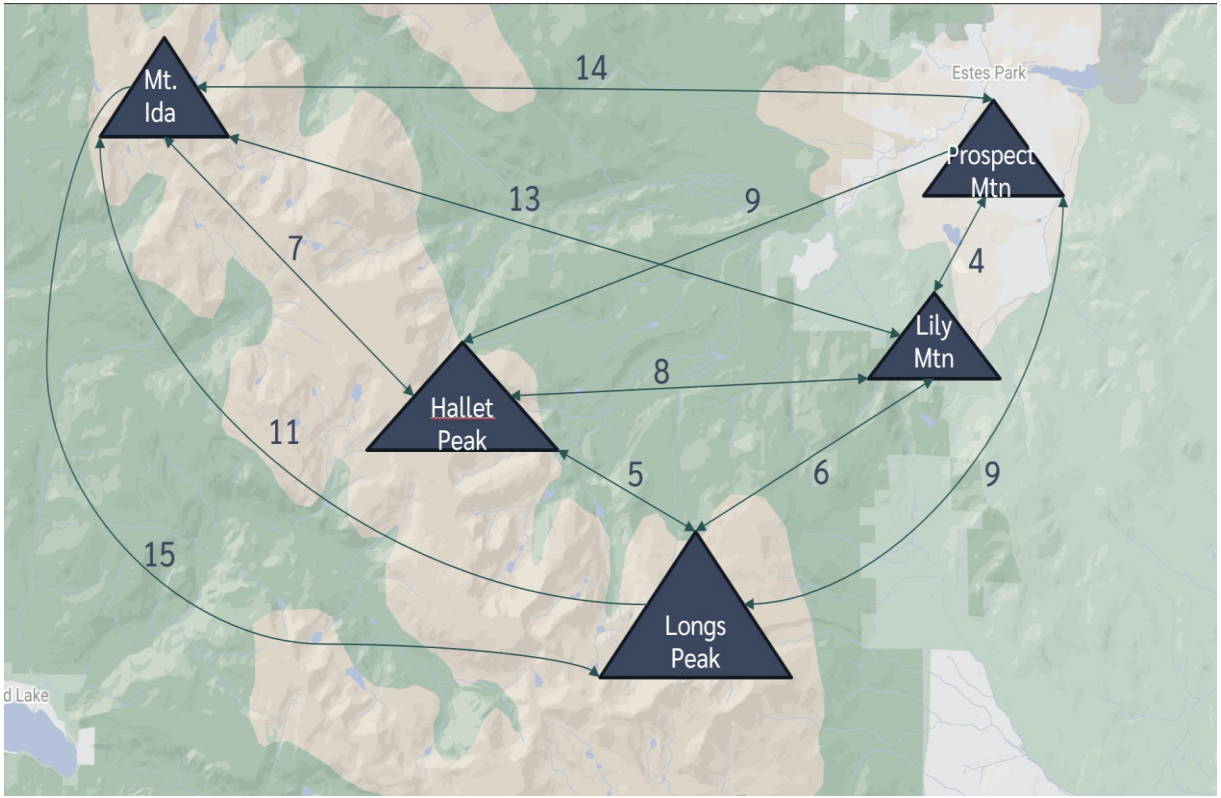
Longs	11	9	5	6	0

```
m⌈.+(⍤1)m
28 24 23 21 23
20 28 21 27 29
23 21 18 20 22
17 27 20 26 28
23 25 18 24 26
```

Longest distance through one stop?



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14  0 9  3  9
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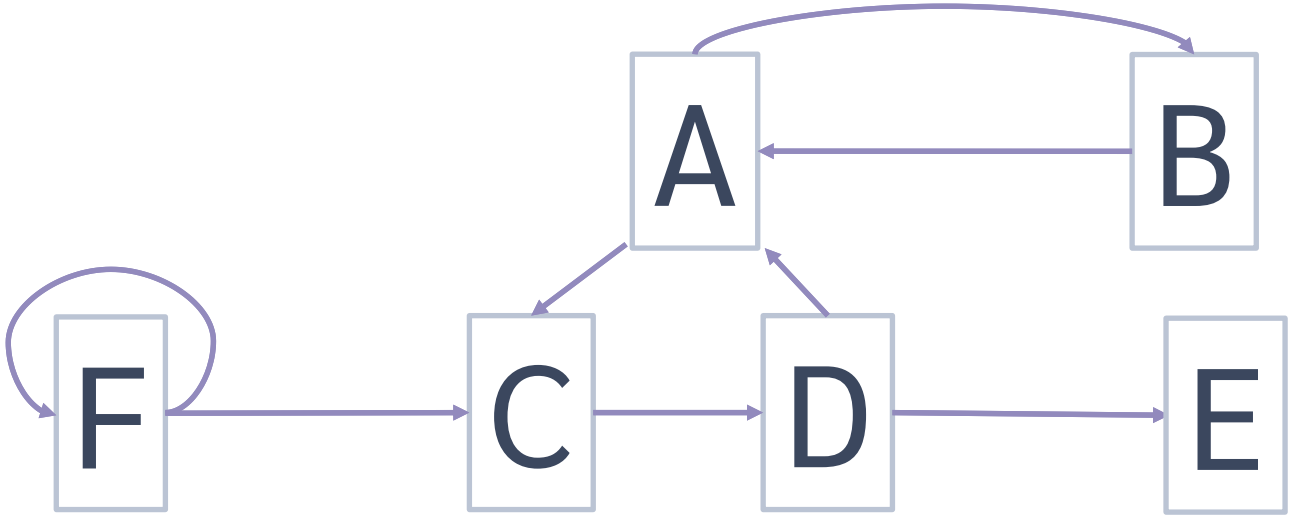
```

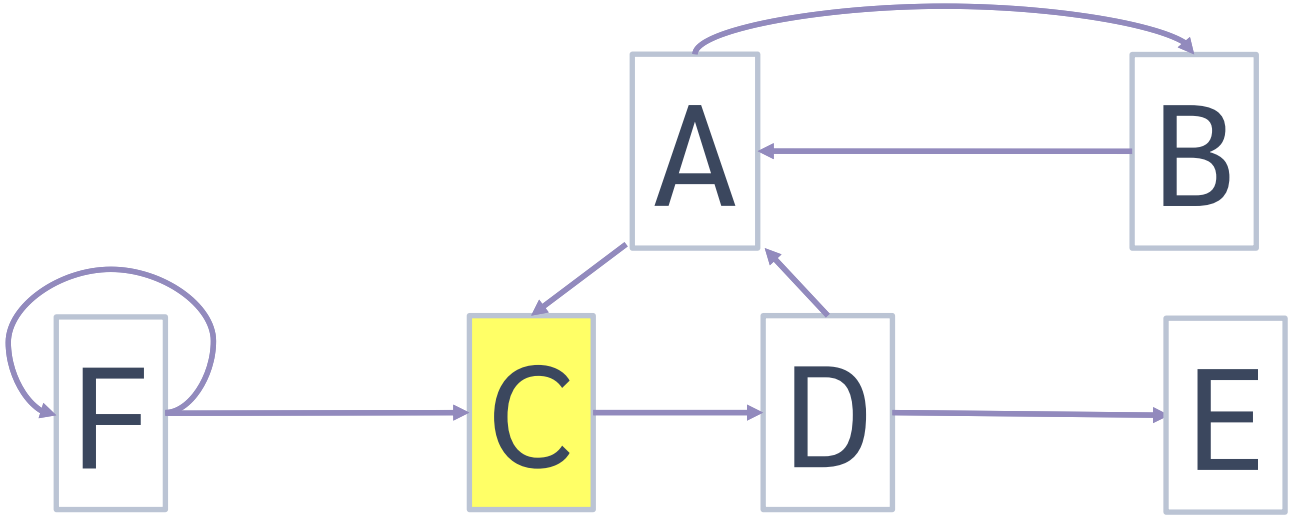
Longest distance through no stops?

Inner Product [Electrical Engineering]



	A	B	C	D	E	F
A	0	1	0	1	0	0
B	1	0	0	0	0	0
C	1	0	0	0	0	1
D	0	0	1	0	0	0
E	0	0	0	1	0	0
F	0	0	0	0	0	1

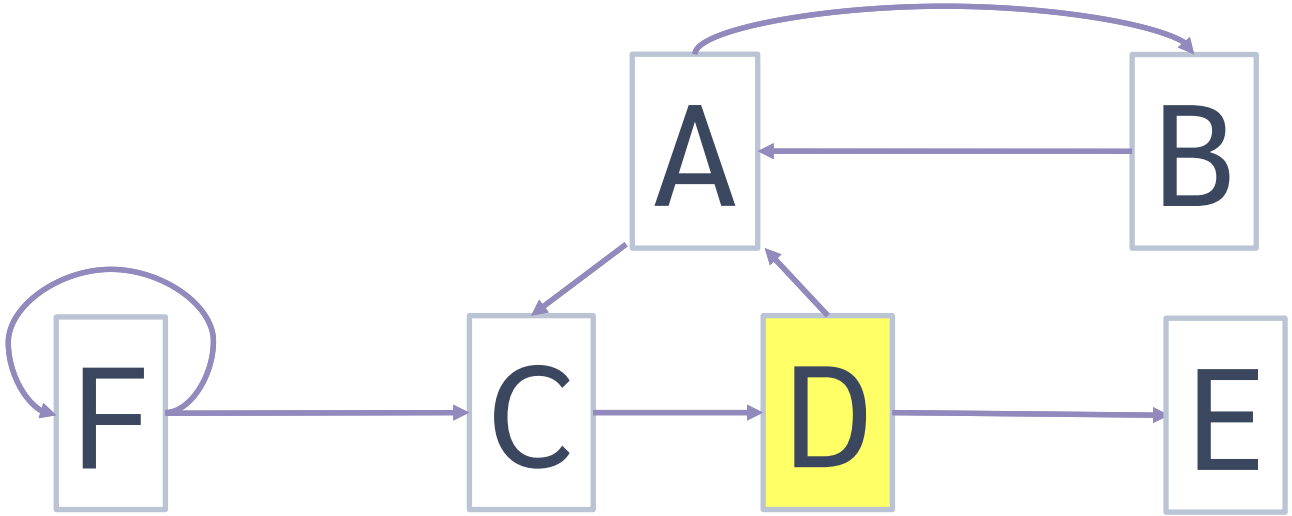
Inner Product [Electrical Engineering]



	A	B	C	D	E	F
A	0	1	0	1	0	0
B	1	0	0	0	0	0
C	1	0	0	0	0	1
D	0	0	1	0	0	0
E	0	0	0	1	0	0
F	0	0	0	0	0	1

```
      s←¯2⌽6↑1
0 0 1 0 0 0
```

Inner Product [Electrical Engineering]



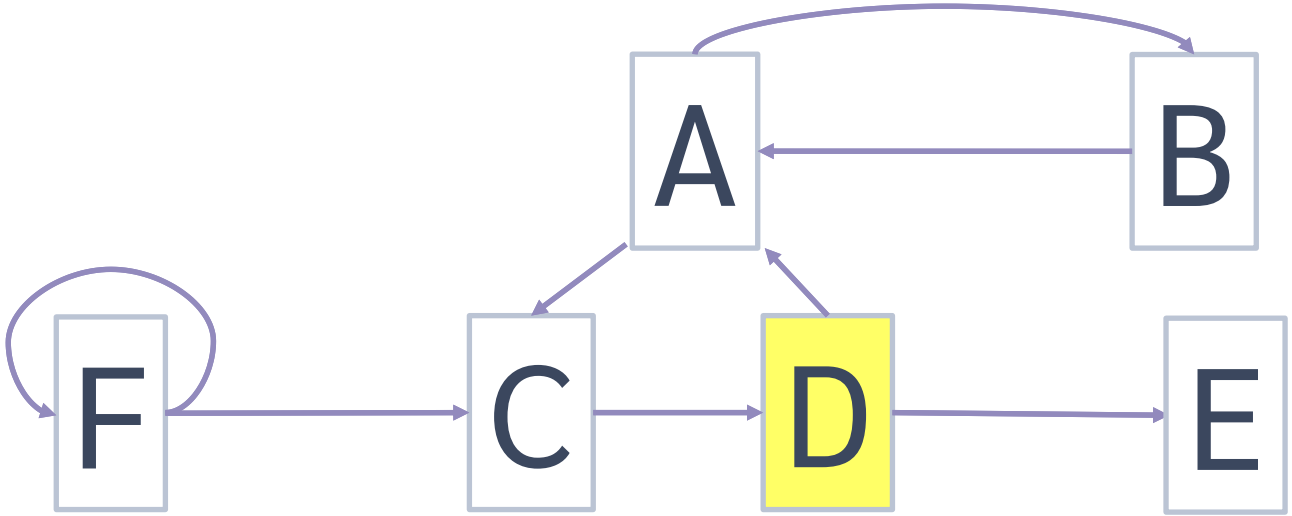
	A	B	C	D	E	F
A	0	1	0	1	0	0
B	1	0	0	0	0	0
C	1	0	0	0	0	1
D	0	0	1	0	0	0
E	0	0	0	1	0	0
F	0	0	0	0	0	1

```
      m ∨.∧ s
0 0 0 1 0 0
A B C D E F
```

```
      s←¯2⌽6↑1
0 0 1 0 0 0
```


Generic Glyphs, Different Domains

Inner Product [Electrical Engineering]

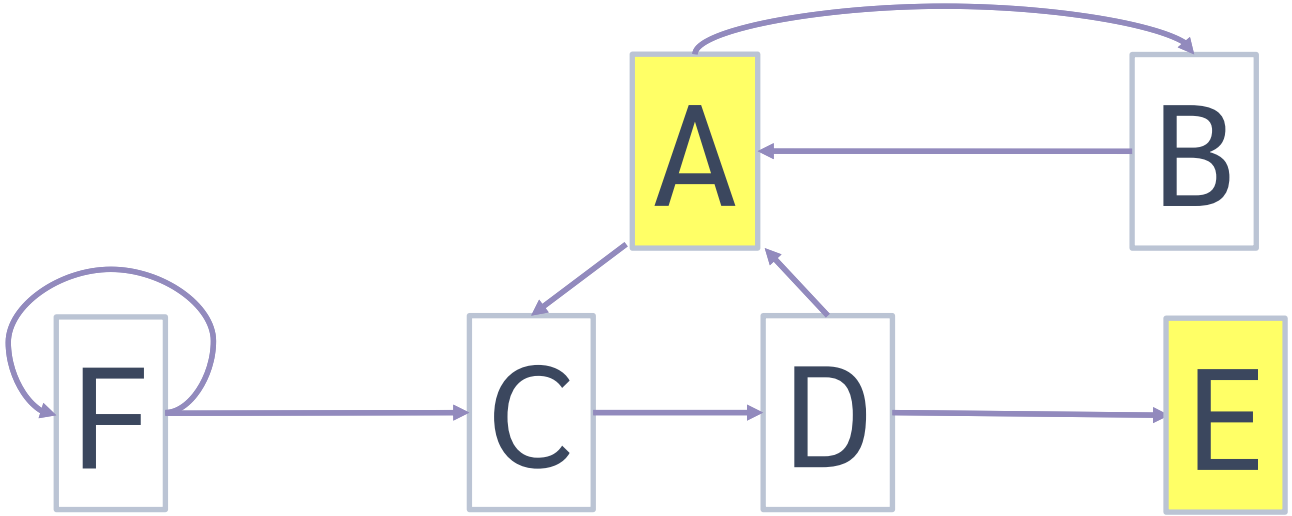


	A	B	C	D	E	F
A	0	1	0	1	0	0
B	1	0	0	0	0	0
C	1	0	0	0	0	1
D	0	0	1	0	0	0
E	0	0	0	1	0	0
F	0	0	0	0	0	1

```
      m ∨.∧(⍤1) s
0 0 0 1 0 0
A B C D E F
```

```
      s←¯2⌽6↑1
0 0 1 0 0 0
```

Inner Product [Electrical Engineering]

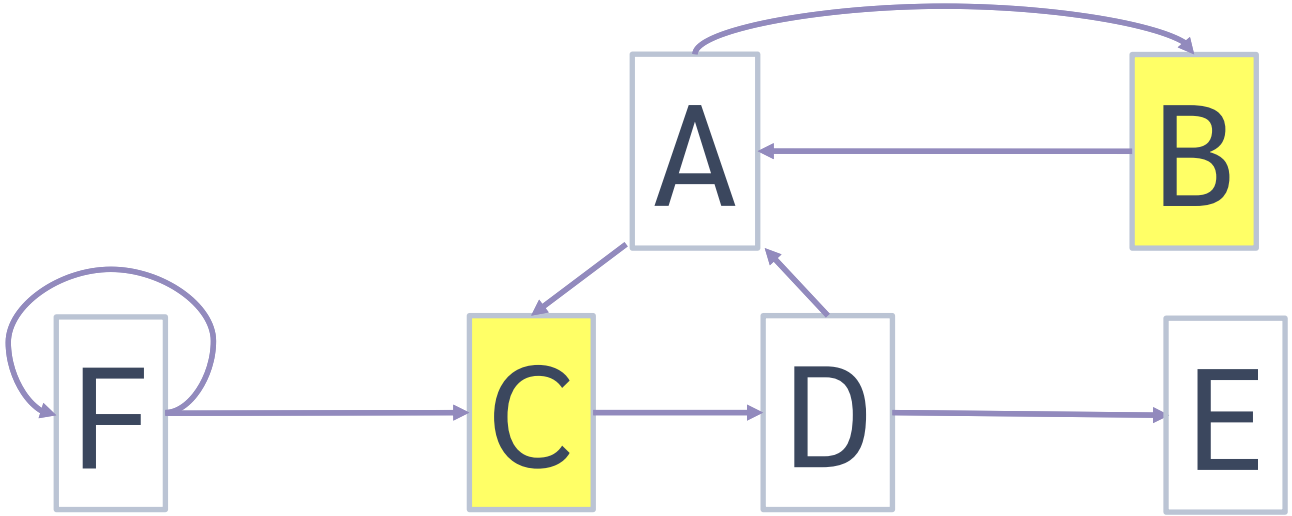


	A	B	C	D	E	F
A	0	1	0	1	0	0
B	1	0	0	0	0	0
C	1	0	0	0	0	1
D	0	0	1	0	0	0
E	0	0	0	1	0	0
F	0	0	0	0	0	1

```
      m ∨.∧(⍤2) s
1 0 0 0 1 0
A B C D E F
```

```
      s←⍨2⊥6↑1
0 0 1 0 0 0
```

Inner Product [Electrical Engineering]

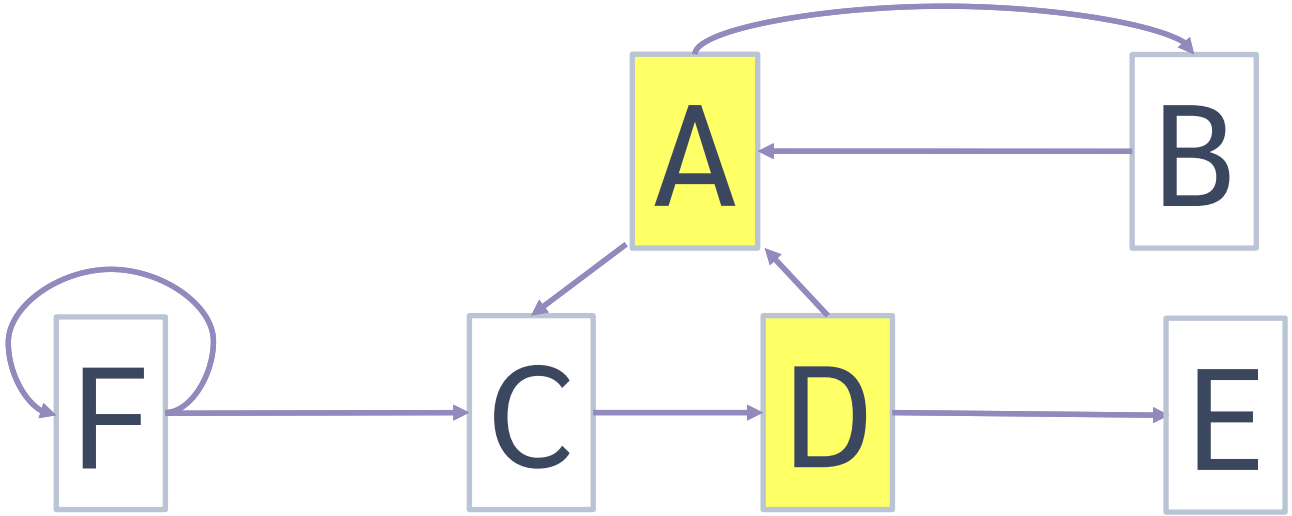


	A	B	C	D	E	F
A	0	1	0	1	0	0
B	1	0	0	0	0	0
C	1	0	0	0	0	1
D	0	0	1	0	0	0
E	0	0	0	1	0	0
F	0	0	0	0	0	1

```
      m ∨.∧(⍤3) s
0 1 1 0 0 0
A B C D E F
```

```
      s←¯2⌽6↑1
0 0 1 0 0 0
```

Inner Product [Electrical Engineering]

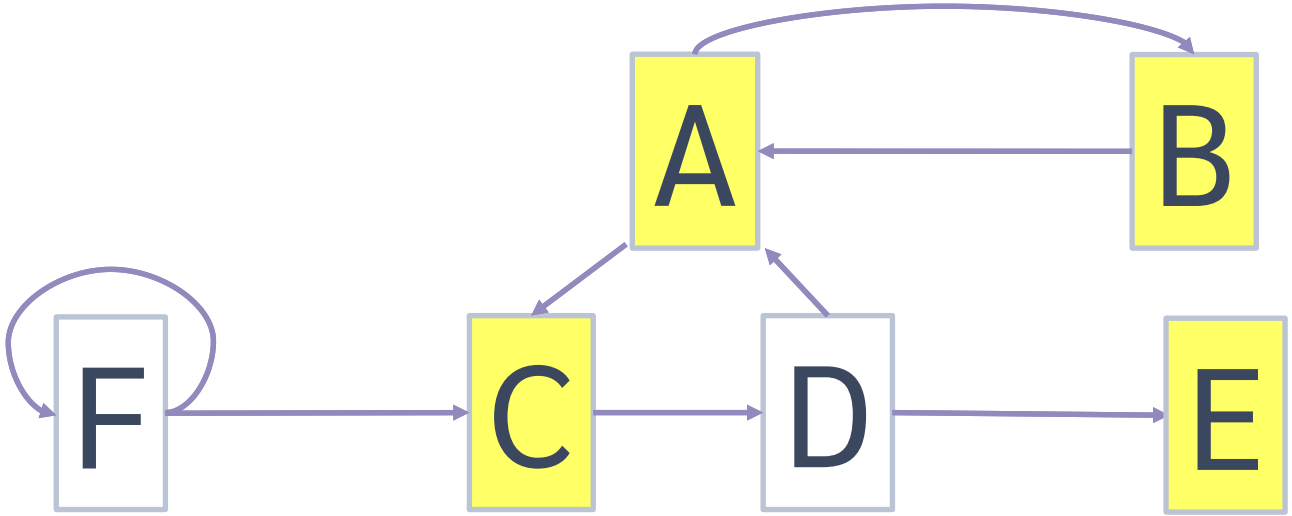


	A	B	C	D	E	F
A	0	1	0	1	0	0
B	1	0	0	0	0	0
C	1	0	0	0	0	1
D	0	0	1	0	0	0
E	0	0	0	1	0	0
F	0	0	0	0	0	1

```
      m ∨.∧(⍤4) s
1 0 0 1 0 0
A B C D E F
```

```
      s←⍉2⊥6↑1
0 0 1 0 0 0
```

Inner Product [Electrical Engineering]

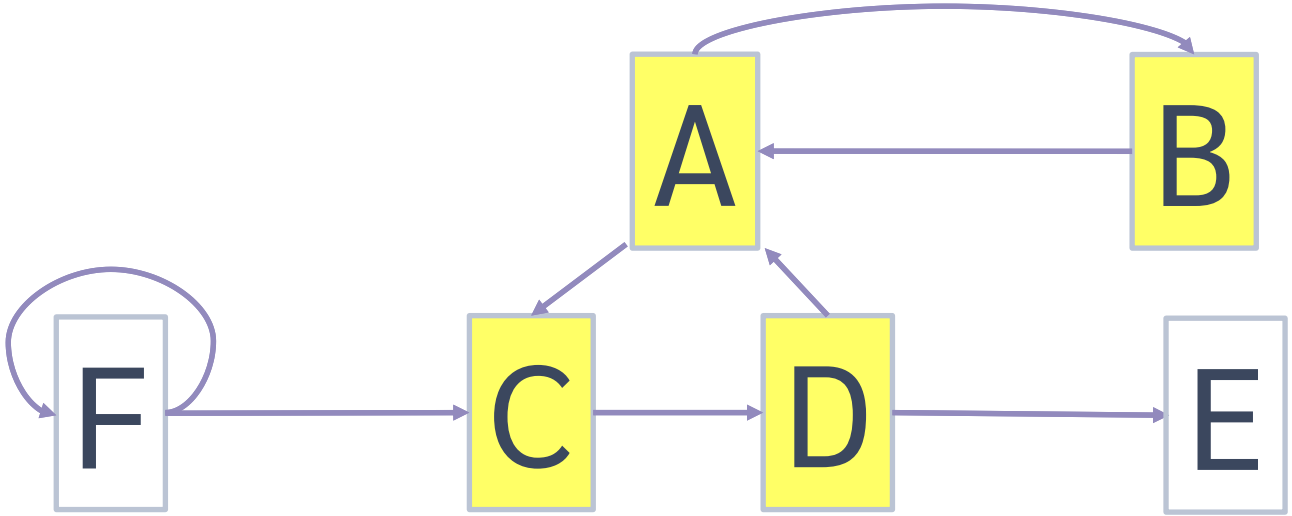


	A	B	C	D	E	F
A	0	1	0	1	0	0
B	1	0	0	0	0	0
C	1	0	0	0	0	1
D	0	0	1	0	0	0
E	0	0	0	1	0	0
F	0	0	0	0	0	1

```
      m ∨.∧(⍤5) s
1 1 1 0 1 0
A B C D E F
```

```
      s←¯2⌽6↑1
0 0 1 0 0 0
```

Inner Product [Electrical Engineering]

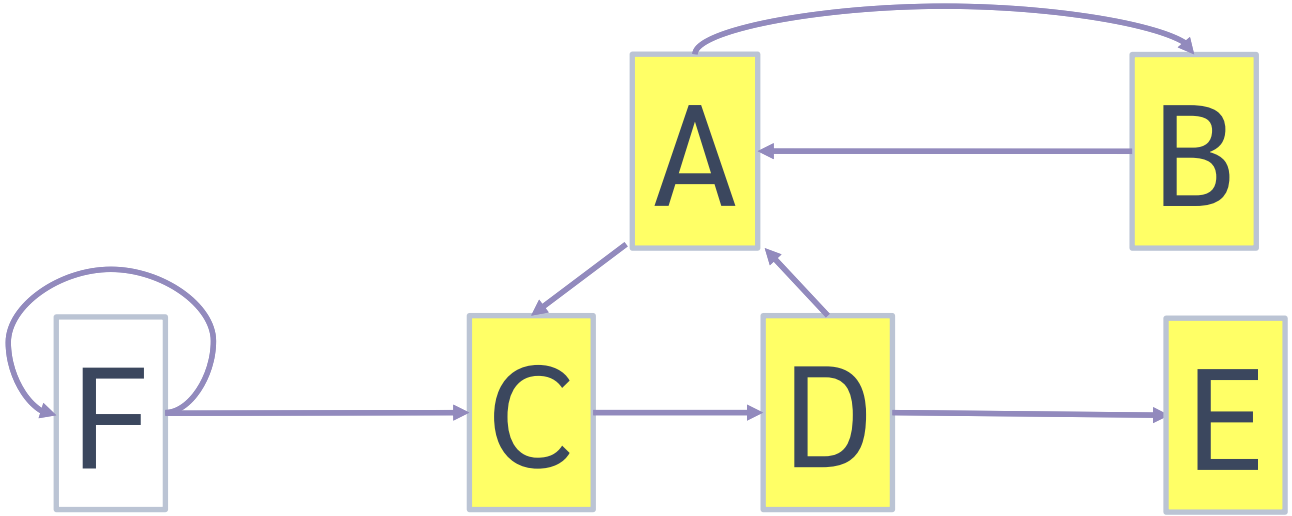


	A	B	C	D	E	F
A	0	1	0	1	0	0
B	1	0	0	0	0	0
C	1	0	0	0	0	1
D	0	0	1	0	0	0
E	0	0	0	1	0	0
F	0	0	0	0	0	1

```
      m ∨.∧(⍤6) s
1 1 1 1 0 0
A B C D E F
```

```
      s←¯2⌽6↑1
0 0 1 0 0 0
```

Inner Product [Electrical Engineering]

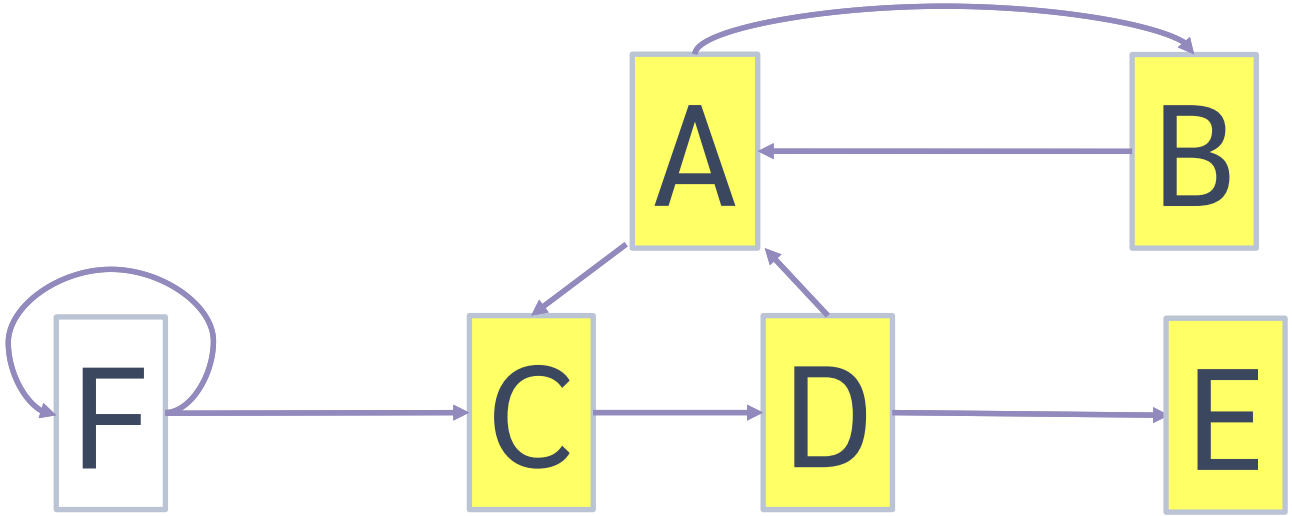


	A	B	C	D	E	F
A	0	1	0	1	0	0
B	1	0	0	0	0	0
C	1	0	0	0	0	1
D	0	0	1	0	0	0
E	0	0	0	1	0	0
F	0	0	0	0	0	1

```
      m ∨.∧(⍤7) s
1 1 1 1 1 0
A B C D E F
```

```
      s←¯2⌽6↑1
0 0 1 0 0 0
```

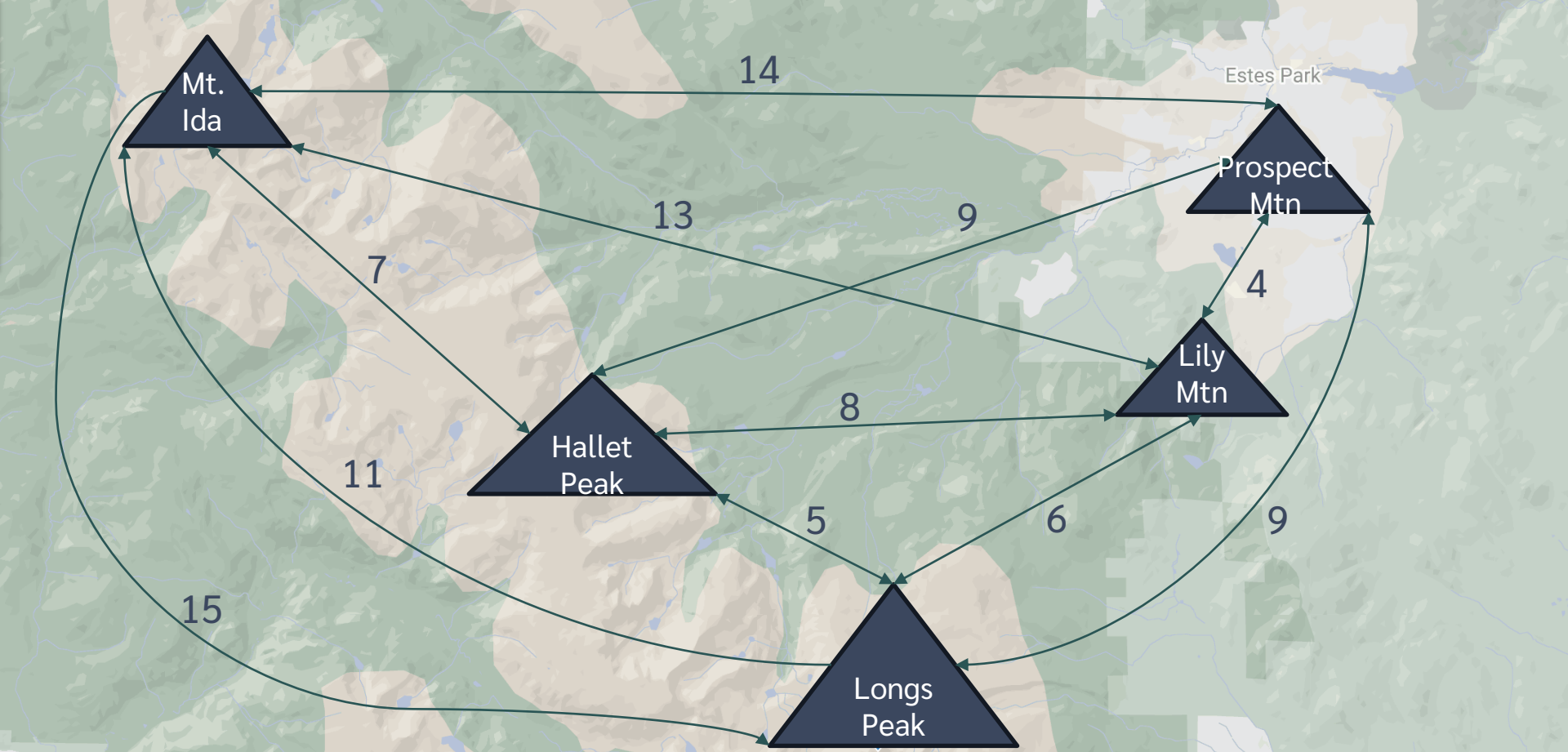
Inner Product [Electrical Engineering]



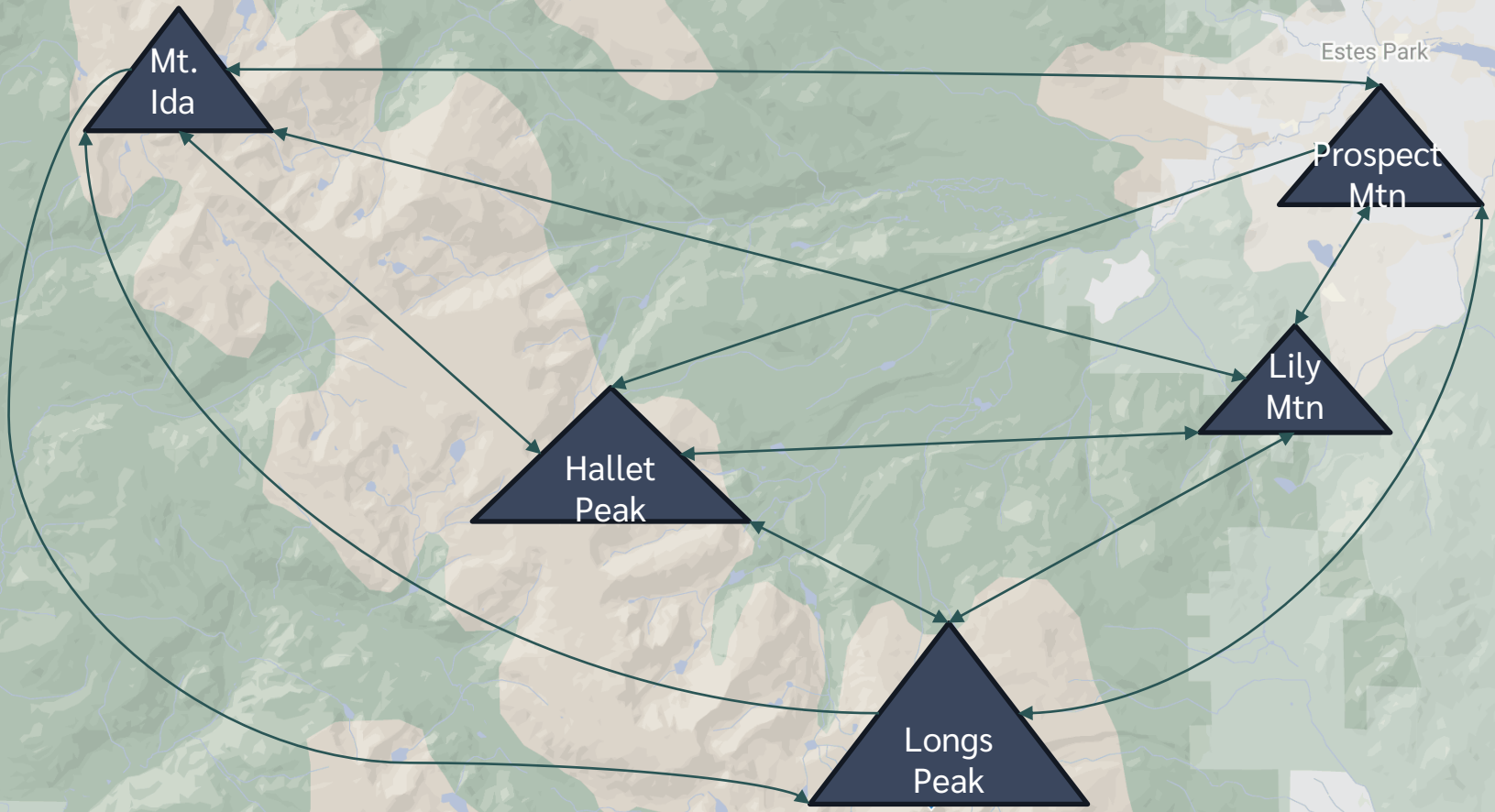
	A	B	C	D	E	F
A	0	1	0	1	0	0
B	1	0	0	0	0	0
C	1	0	0	0	0	1
D	0	0	1	0	0	0
E	0	0	0	1	0	0
F	0	0	0	0	0	1

```
      m ∨.∧(⍤≡) s
1 1 1 1 1 0
A B C D E F
```

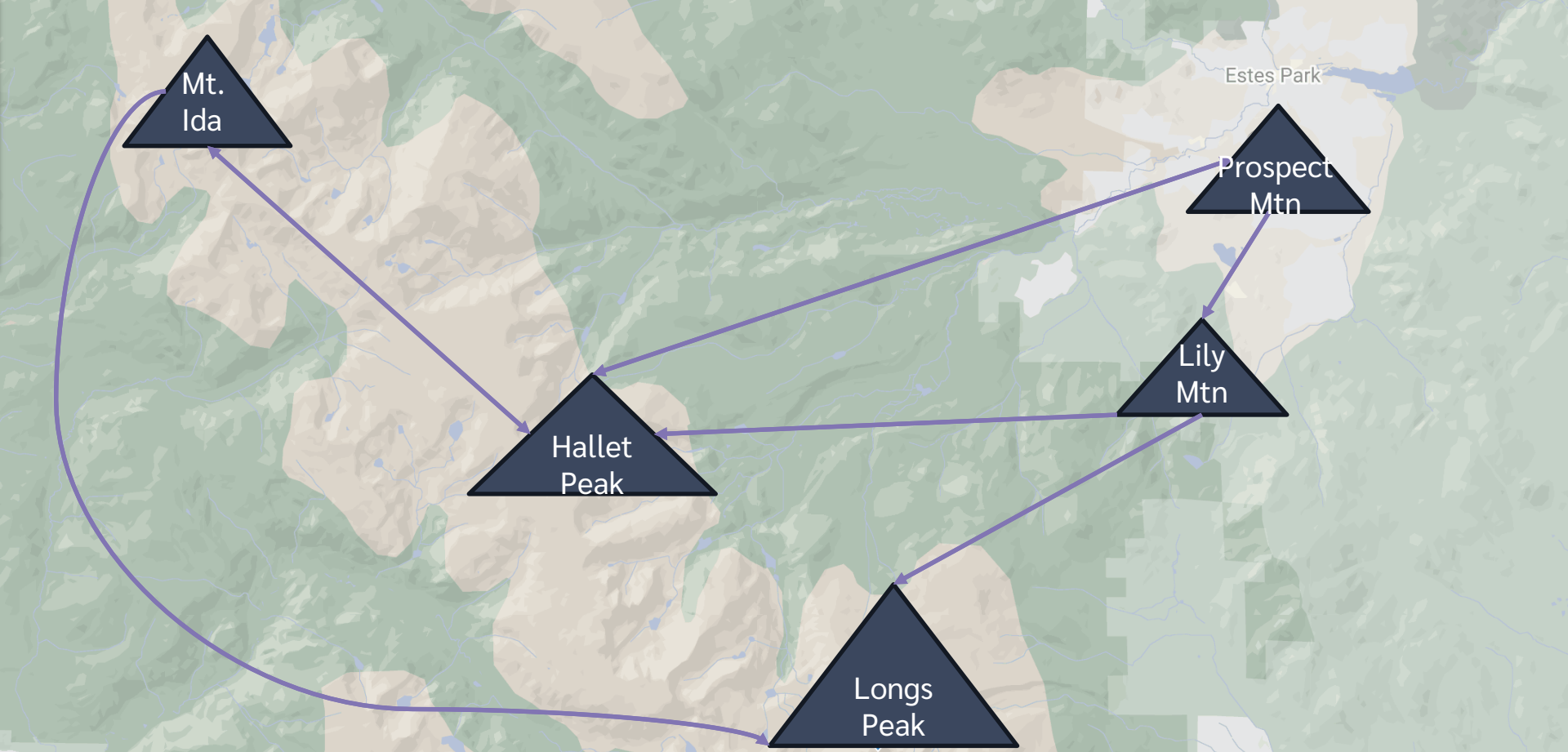
```
      s←¯2⍧6↑1
0 0 1 0 0 0
```



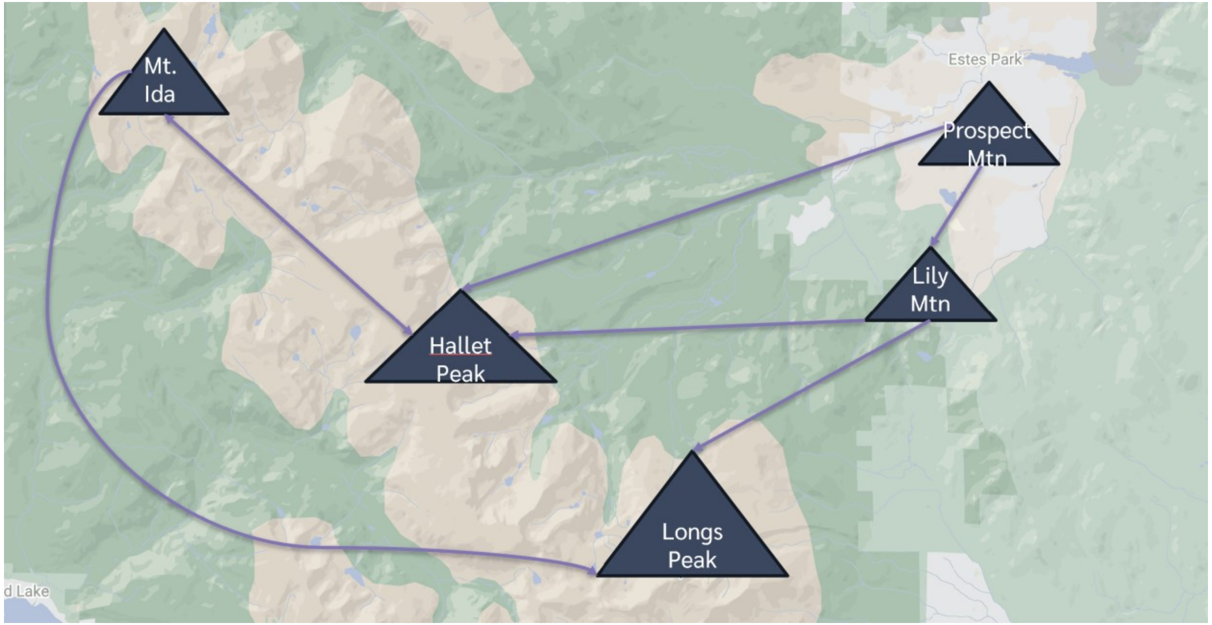
Generic Glyphs, Different Domains



Generic Glyphs, Different Domains



Generic Glyphs, Different Domains



	Ida	Prospect	Hallet	Lily	Longs
Ida	0	0	1	0	1
Prospect	0	0	1	1	0
Hallet	1	0	0	0	0
Lily	0	0	1	0	1
Longs	0	0	0	0	0

```
      (∨.∧⍨∨⊢)⍣≡m
1 0 1 0 1
1 0 1 1 1
1 0 1 0 1
1 0 1 0 1
0 0 0 0 0
```

Which peaks can be reached from any location?

Text matching

ABCD

EFGH

IJKL

Text matching

```
      '.',(⍕2) 3 4 ⍴ ⎕A
..ABCD
..EFGH
..IJKL
```

Text matching

```
      '.',(⍕2) 3 4 ⍴ ⎕A
..ABCD
..EFGH
..IJKL
      '.'^.='.',(⍕2) 3 4 ⍴ ⎕A
1 1 0 0 0 0
```

Chemistry [Dimensional Analysis]

```
      mL2L ← ÷∘1000
      L2mL ← mL2L ⍣¯1
      C2F ← (32∘+)∘(×∘1.8)
      F2C ← C2F ⍣¯1
      C2F ¯40 0 100
¯40 32 212
      F2C ¯40 32 212
¯40 0 100
```

```
F2C(⍣isMetricSystem)
      ⍣
   ┌──┴──┐
   ⍣     1
┌──┴──┐
∘     ¯1
┌─────┴─────┐
∘           ∘
┌──┴──┐  ┌──┴──┐
32    +  ×    1.8
```

BioInformatics: DNA to mRNA

```
      d ← 'ATCG'
      r ← 'UAGC'
      dna2rna ← {r[d⍳⍵]}
      dna2rna 'AAGCTGGTTTTGACGAC'
UUCGACCAAAACUGCUG
      dna2rna ← {(r,'?')[d⍳⍵]}
      dna2rna 'AAG#!2⊛TTTTGACxyz'
UUC???AAAACUG???
```

Bioinformatics: DNA-view

Y match calculation #1 (primitive)

```
matchpr←n ConvMut (gen mu)
⍝ Probability of Convergent Mutation at a locus
⍝ Pr(two haplotypes gen generations apart match)
⍝ n = # of (cancelling) mutation pairs
⍝ mu = Pr(mutation) at each generation

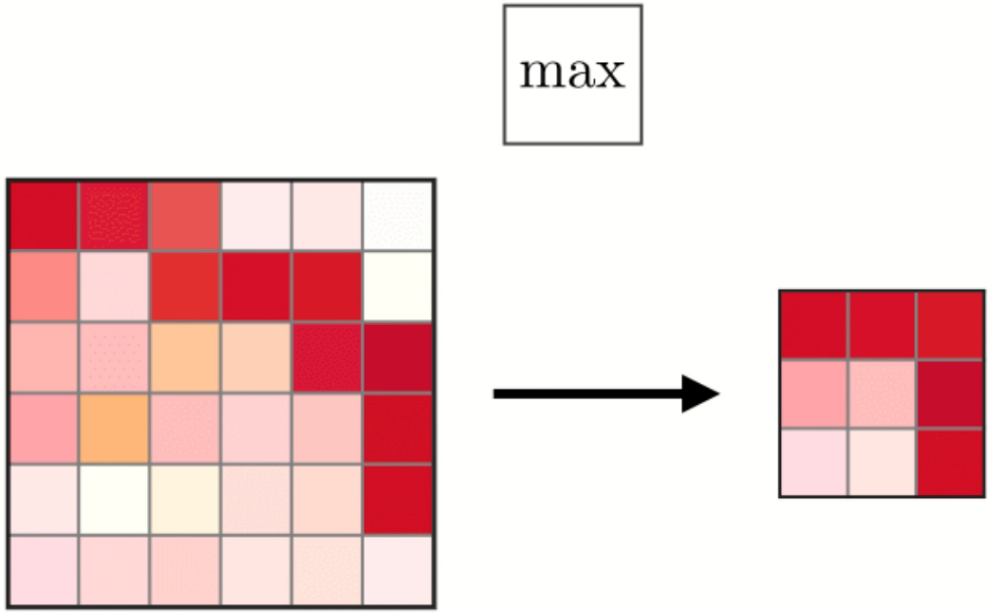
ways←n×.!gen,gen-n                    ⍝ ways to position mutations
pr←(mu÷2)(1-mu)×.*(2×n)(gen-2×n)      ⍝ probability of each way
matchpr ← ways×pr                     ⍝ total probability of all ways
```

https://dnaview.com/

Text Analysis

```
      s ← 'a (qu)ick de(mo(nstra()ti)o)n'
      +\1 ¯1 0['()'⍳s]
0 0 1 1 1 0 0 0 0 0 0 0 1 1 1 2 2 2 2 2 2 3 2 2 2 1 1 0 0
      ⊖s,⍪+\1 ¯1 0['()'⍳s]
0 0 1 1 1 0 0 0 0 0 0 0 1 1 1 2 2 2 2 2 2 3 2 2 2 1 1 0 0
a   ( q u ) i c k   d e ( m o ( n s t r a ( ) t i ) o ) n
```


Image Processing Unet CNN




```
{⌈⍲,⍵}⌺(2 2⍴2)⊢m
```

https://stanford.edu/~shervine/teaching/cs-230/cheatsheet-convolutional-neural-networks

Acknowledgements

- APL an Interactive Approach, Gilman & Rose
- Mastering Dyalog APL, Bernard Legrand
- Mark Wolfson
- Dr. Charles Brenner
  - https://www.dyalog.com/uploads/conference/dyalog18/presentations/U13_Simplicity_May_Be_Confusing.pdf
- Marcos Frenkel, NCSA/University of Illinois at Urbana-Champaign
  - https://www.dyalog.com/uploads/conference/dyalog23/materials/U08_quAPLAQuantumComputingLibraryInAPL.pdf