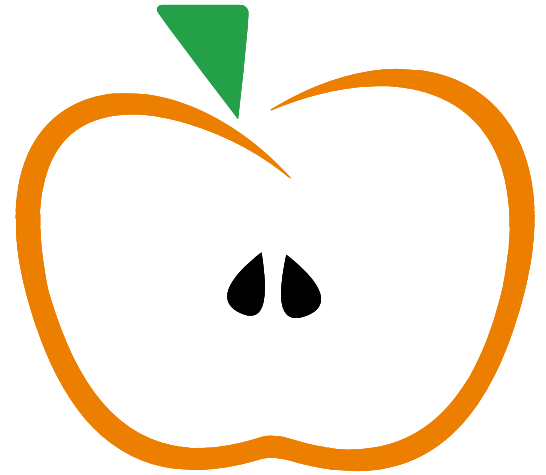


DIALOG

APL Seeds 2023

The Heart of the Algorithm

Rich Park



Versatile Building Blocks

Mathematics

+ - × ÷ [] * ! | ⊗ ○ ⊞ ⊥ τ ?

Logic and Comparison

~ ^ v ã ã < > ≤ ≥ = ≠ ≡ ≠

Structural

ρ , , ϕ θ ϑ ↑ ↓ ⊂ ⊆ ≡ ∈

Selection and Set Operations

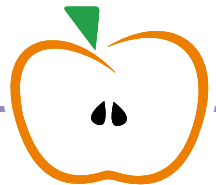
[] ⊃ / ≠ \ ≠ ~ ≠ ∪ ∩ → ←

Search and Ordering

⊥ ⊂ ∈ ⊆ ⊆ ⊆

Operators

.. ~ * . ° / \ ≠ ≠ ⊞ ⊞ ⊞ @ ⊞



Versatile Building Blocks

Mathematics

+ - × ÷ [] * ! | ⊗ ○ ⊞ ⊥ ⊤ ?

Logic and Comparison

~ ^ v ~ ~ < > ≤ ≥ = ≠ ≡ ≠

Structural

ρ , , ϕ θ ϑ ↑ ↓ < ≤ ≡ ∈

Selection and Set Operations

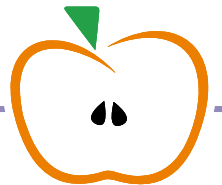
□ ⊃ / ≠ \ ≠ ~ ≠ ∪ ∩ → ⊆

Search and Ordering

⌊ ⌋ ∈ ⊆ ⊆ ⊆ ⊆

Operators

.. ~ * . ° / \ ≠ ≠ ⊞ ⊞ ⊞ ⊞ ⊞



Simple syntax

two-argument, infix: **dyadic** functions

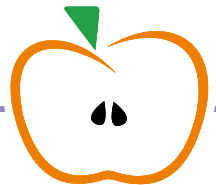
15 3 × 5

-2 3 - 5

one-argument, prefix: **monadic** functions

-6 -3 0 12 - 6 3 0 -12

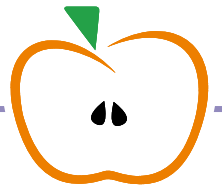
1 2 3 4 5 6 7 ι 7



Simple syntax

Short left scope; long right scope

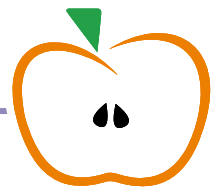
								ι	7	
1	2	3	4	5	6	7				
							2	×	ι	7
2	4	6	8	10	12	14				
				-1	+	2	×	ι	7	
1	3	5	7	9	11	13				



Simple syntax

Short left scope, long right scope

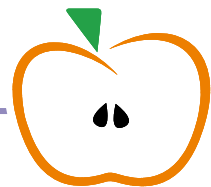
`-1 + 2 * 7`



Simple syntax

Short left scope, long right scope

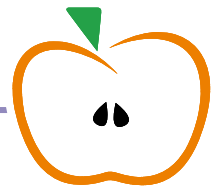
$-1 + 2 \times 7$



Simple syntax

Short left scope, long right scope

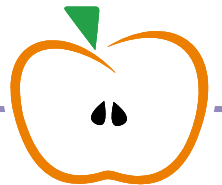
$-1 + 2 \times 1 2 3 4 5 6 7$



Simple syntax

Short left scope, long right scope

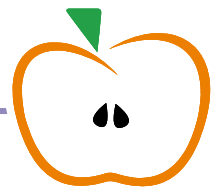
$-1 + 2 4 6 8 10 12 14$



Simple syntax

Short left scope, long right scope

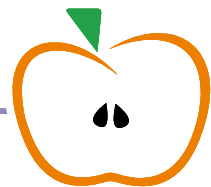
1 3 5 7 9 11 13



Operators

How to sum a list

$$2 + 5 + 8 + -4 + 6$$



Operators

How to sum a list

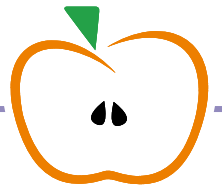
$$2 + 5 + 8 + -4 + 6$$

$$2 + 5 + 8 + 2$$

$$2 + 5 + 10$$

$$2 + 15$$

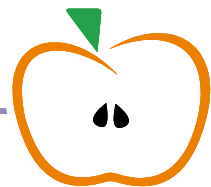
$$17$$



Operators

How to sum a list

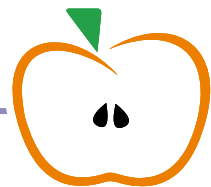
2 5 8 -4 6



Operators

How to sum a list

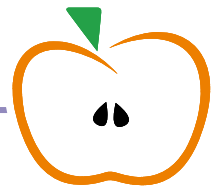
17 + / 2 5 8 -4 6



Operators

How to sum a list

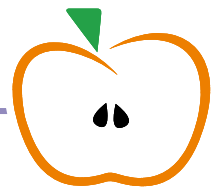
+ / 2 5 8 -4 6



Operators

How to sum a list

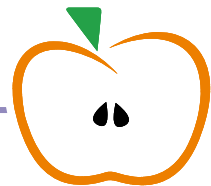
$\times /$ 2 5 8 -4 6
 -1920



Operators

How to sum a list

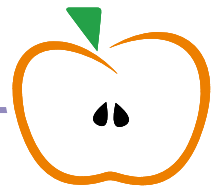
8 [/ 2 5 8 -4 6



Operators

How to sum a list

-4 $[-4, 2, 5, 8, -4, 6]$

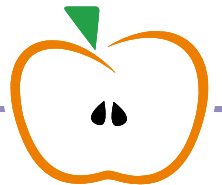


Operators

Outer Product

1 2 3 \circ \cdot \times 1 2 3 4 5

1	2	3	4	5
2	4	6	8	10
3	6	9	12	15

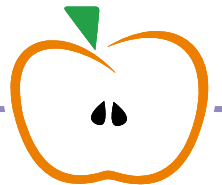


Operators

Outer Product

1 2 3 \circ \cdot \times 1 2 3 4 5

1	2	3	4	5
2	4	6	8	10
3	6	9	12	15

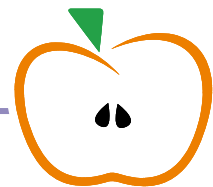


Operators

Outer Product

1 2 3 ◦ . + 1 2 3 4 5

2 3 4 5 6
3 4 5 6 7
4 5 6 7 8

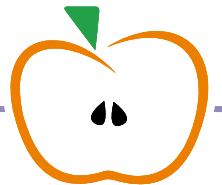


Operators

Outer Product

1 2 3 \circ . = 1 2 3 4 5

1	0	0	0	0
0	1	0	0	0
0	0	1	0	0

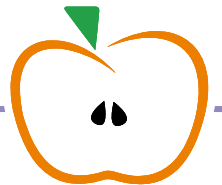


Operators

Outer Product

1 2 3 \circ \cdot \geq 1 2 3 4 5

1	0	0	0	0
1	1	0	0	0
1	1	1	0	0

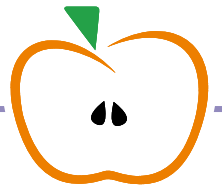


Booleans

Friendly 1s and 0s

1 2 3 ◦ . ≥ 1 2 3 4 5

1	0	0	0	0
1	1	0	0	0
1	1	1	0	0

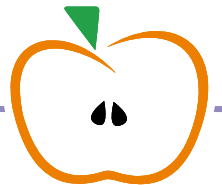


Booleans

Friendly 1s and 0s

+ / 1 2 3 ◦ . ≥ 1 2 3 4 5

1	0	0	0	0
1	1	0	0	0
1	1	1	0	0



Booleans

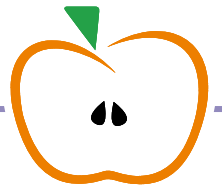
Friendly 1s and 0s

+ / 1 2 3 ° . ≥ 1 2 3 4 5

1

2

3

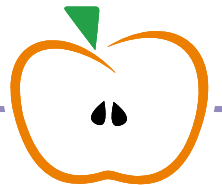


Booleans

Friendly 1s and 0s

+ / 1 2 3 ° . ≥ 1 2 3 4 5

1 2 3

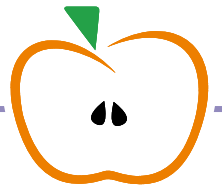


Booleans

Friendly 1s and 0s

+ / 1 2 3 ° . ≥ 1 2 3 4 5

1	0	0	0	0
1	1	0	0	0
1	1	1	0	0

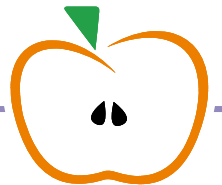


Booleans

Friendly 1s and 0s

+ / 1 2 3 ° . ≥ 1 2 3 4 5

1	0	0	0	0
1	1	0	0	0
1	1	1	0	0



Booleans

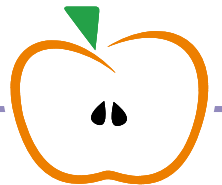
Friendly 1s and 0s

+ / 1 2 3 ° . ≥ 1 2 3 4 5

1 0 0 0 0

1 1 0 0 0

1 1 1 0 0

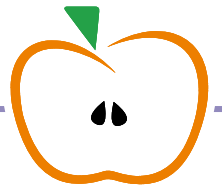


Booleans

Friendly 1s and 0s

+ / 1 2 3 ° . ≥ 1 2 3 4 5

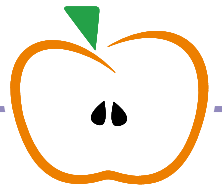
3 2 1 0 0



Who Attended Online User Meetings?

Dyalog had online user meetings in 2020 and 2021.
`attendees.csv` records when each attendee joined or left:

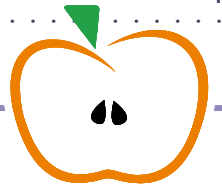
Attendee	Join Time	Leave Time
Jaslyn Chapman	11/9/2020 15:18	11/9/2020 18:04
Jaslyn Chapman	11/9/2020 13:57	11/9/2020 15:18
Dalia Gentry	11/9/2020 13:59	11/9/2020 19:03
Mark Cannon	11/9/2020 15:42	11/9/2020 16:16



Who Attended Online User Meetings?

Dyalog had online user meetings in 2020 and 2021.
`schedule.csv` records the beginning and end times for sessions:

Session	Title	Start Time	End Time
2020-D01	Welcome to Dyalog '20	11/9/2020 14:00	11/9/2020 14:15
2020-D02	The Road Ahead	11/9/2020 14:15	11/9/2020 15:00
2020-D03	Multi-line Input and Scripting	11/9/2020 15:15	11/9/2020 15:45
2020-D04	The .NET Core Bridge	11/9/2020 15:45	11/9/2020 16:15



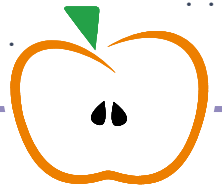
Who Attended Online User Meetings?

Return a Boolean matrix (2D array):

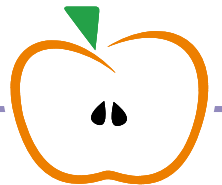
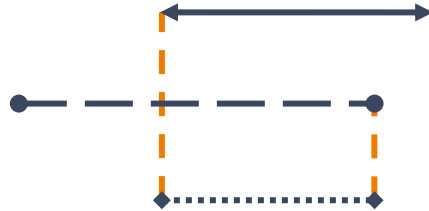
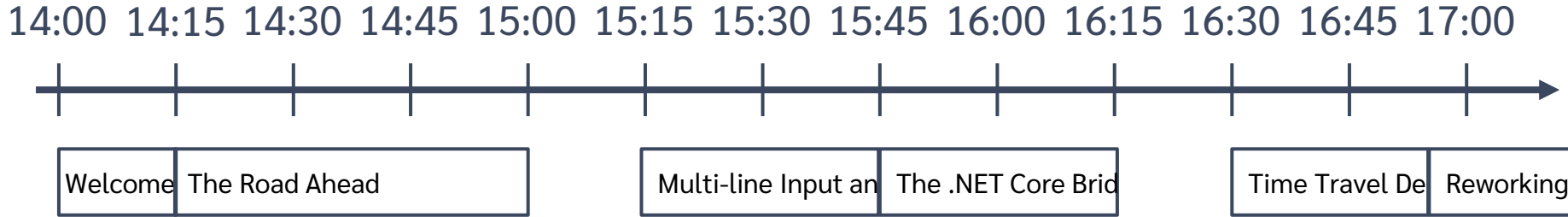
- Rows represent unique attendees.
- Columns represent sessions.

1 indicates attending *at least half* of the duration of a session.

	Welcome t..	The Road ..	Multi-lin..	The .NET ..	Time Trav..	Reworking..
Jaslyn..	1	1	1	1	1	1
Dalia ..	1	1	1	1	1	1
Mark C..	0	0	0	1	0	0
Braely..	1	1	1	1	1	1



Compare times



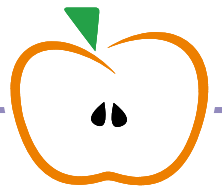
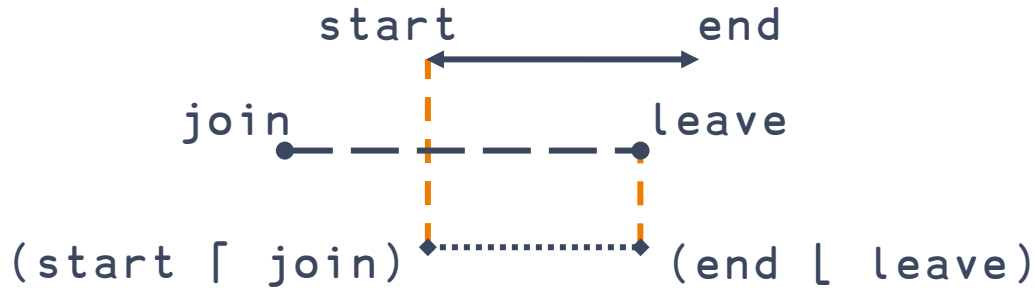
Compare times



Welcome | The Road Ahead

Multi-line Input and | The .NET Core Brid

Time Travel De | Reworking Ma



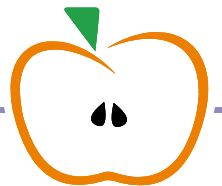
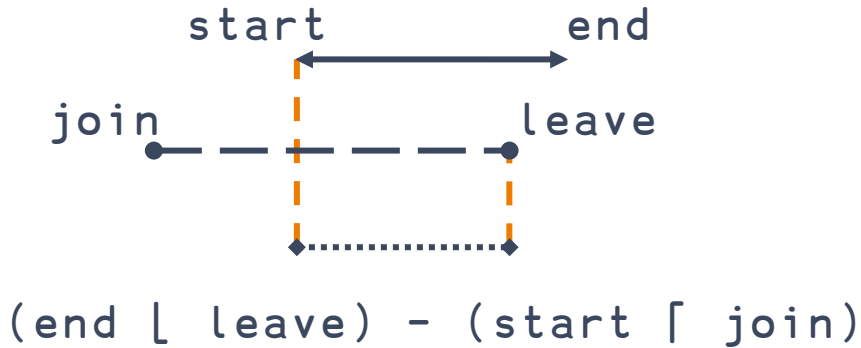
Compare times



Welcome | The Road Ahead

Multi-line Input and | The .NET Core Brid

Time Travel De | Reworking Ma



Compare times

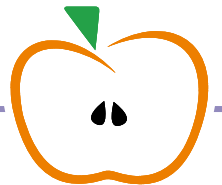
14:00 14:15 14:30 14:45 15:00 15:15 15:30 15:45 16:00 16:15 16:30 16:45 17:00



Welcome | The Road Ahead

Multi-line Input an | The .NET Core Brid

Time Travel De | Reworking Ma



Compare times

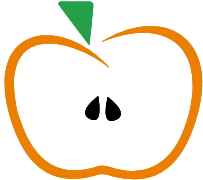
14:00 14:15



15:15 15:45



16:30 16:55



Compare times

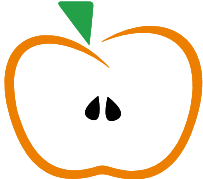
14:00 14:15



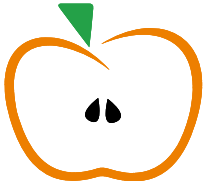
15:15 15:45



16:30 16:55

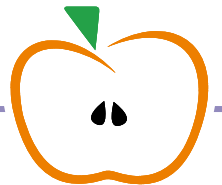


Compare times

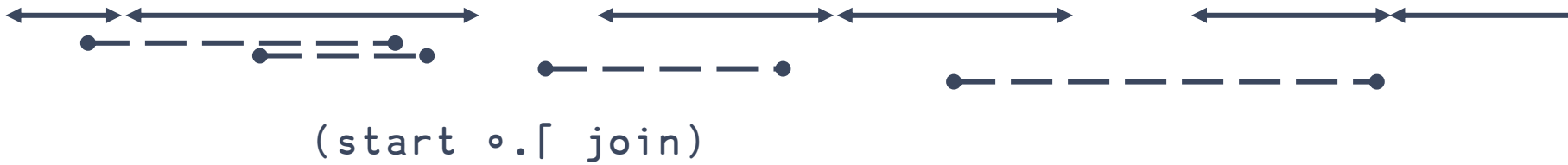


Compare times

	⌘	⌘	⌘	⌘	⌘	⌘
	•	•	•	•	•	•
	(start ◦.⌈ join)					
	14:13	14:29	15:08	16:00		
14:00	14:13	14:29	15:08	16:00		
14:15	14:15	14:29	15:08	16:00		
15:15	15:15	15:15	15:15	16:00		
15:45	15:45	15:45	15:45	16:00		
16:30	16:30	16:30	16:30	16:30		
16:55	16:55	16:55	16:55	16:55		



Compare times

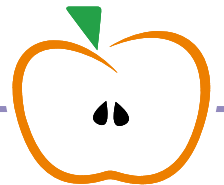


14:13
14:15
15:15
15:45
16:30
16:55

14:29
14:29
15:15
15:45
16:30
16:55

15:08
15:08
15:15
15:45
16:30
16:55

16:00
16:00
16:00
16:00
16:30
16:55

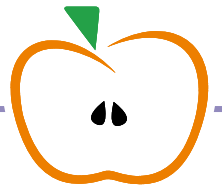


Compare times



(start ◦. [join)

14:13	14:29	15:08	16:00
14:15	14:29	15:08	16:00
15:15	15:15	15:15	16:00
15:45	15:45	15:45	16:00
16:30	16:30	16:30	16:30
16:55	16:55	16:55	16:55

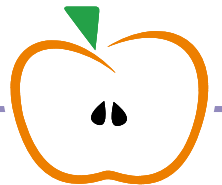


Compare times



`(end ◦.⌊ leave) - (start ◦.⌈ join)`

14:13	14:29	15:08	16:00
14:15	14:29	15:08	16:00
15:15	15:15	15:15	16:00
15:45	15:45	15:45	16:00
16:30	16:30	16:30	16:30
16:55	16:55	16:55	16:55

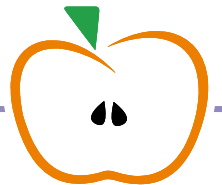


Compare times



`(end ◦.⌊ leave) - (start ◦.⌈ join)`

120	-840	-3180	-6300
2220	1560	-480	-3600
-1380	-1200	1620	-900
-3180	-3000	-180	900
-5880	-5700	-2880	1500
-7380	-7200	-4380	0

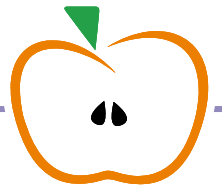


Compare times



$(\text{end} \circ .\lfloor \text{leave}) - (\text{start} \circ .\lceil \text{join})$

120	-840	-3180	-6300
2220	1560	-480	-3600
-1380	-1200	1620	-900
-3180	-3000	-180	900
-5880	-5700	-2880	1500
-7380	-7200	-4380	0

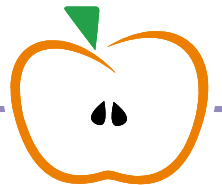


Compare times



`(end ◦.⌊ leave) - (start ◦.⌈ join)`

120	-840	-3180	-6300
2220	1560	-480	-3600
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-3180	-3000	-180	900
-5880	-5700	-2880	1500
-7380	-7200	-4380	0

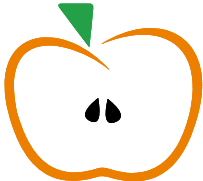


Compare times



end - start

900 2700 1800 1800 1500 1200



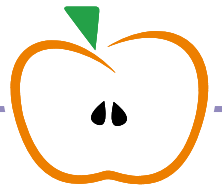
Compare times



$$(0.5 \times \text{end} - \text{start}) \leq (\text{end} \circ .[\text{leave}) - (\text{start} \circ .[\text{join})$$

^

RANK ERROR: Mismatched left and right argument ranks



Compare times



$$(0.5 \times \text{end} - \text{start}) \leq (\text{end} \circ . \lfloor \text{leave}) - (\text{start} \circ . \lceil \text{join})$$

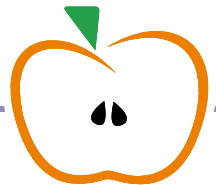
900 2700 1800 1800 1500 1200

120
2220
-1380
-3180
-5880
-7380

-840
1560
-1200
-3000
-5700
-7200

-3180
-480
1620
-180
-2880
-4380

-6300
-3600
-900
900
1500
0



Compare times



$(0.5 \times \text{end} - \text{start})$ (≤ 0 1) ($\text{end} \circ \lfloor \text{leave}$) - ($\text{start} \circ \lceil \text{join}$)

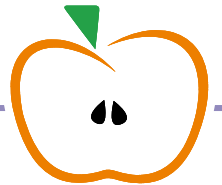
900 2700 1800 1800 1500 1200

120
2220
-1380
-3180
-5880
-7380

-840
1560
-1200
-3000
-5700
-7200

-3180
-480
1620
-180
-2880
-4380

-6300
-3600
-900
900
1500
0



Compare times



$(0.5 \times \text{end} - \text{start})$ (≤ 0 1) ($\text{end} \circ \lfloor \text{leave}$) - ($\text{start} \circ \lceil \text{join}$)

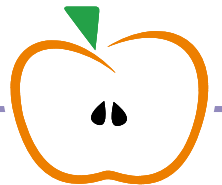
900 2700 1800 1800 1500 1200

120
2220
-1380
-3180
-5880
-7380

-840
1560
-1200
-3000
-5700
-7200

-3180
-480
1620
-180
-2880
-4380

-6300
-3600
-900
900
1500
0

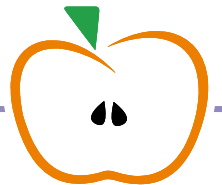


Compare times



$$(0.5 \times \text{end} - \text{start}) \leq 0 \quad 1) \quad (\text{end} \circ . \lfloor \text{leave}) - (\text{start} \circ . \lceil \text{join})$$

900		120		-840		-3180		-6300
2700		2220		1560		-480		-3600
1800		-1380		-1200		1620		-900
1800	≤	-3180		-3000		-180		900
1500		-5880		-5700		-2880		1500
1200		-7380		-7200		-4380		0

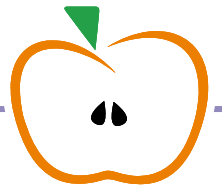


Compare times



$(0.5 \times \text{end} - \text{start}) \ (\leq 0 \ 1)$ $(\text{end} \circ \lfloor \text{leave}) - (\text{start} \circ \lceil \text{join})$

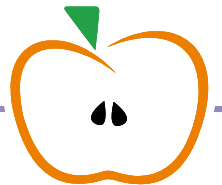
0	0	0	0
1	1	0	0
0	0	1	0
0	0	0	1
0	0	0	1
0	0	0	0



Compare times

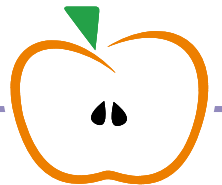


$(0.5 \times \text{end} - \text{start}) (\leq 0 \ 1)$ $(\text{end} \circ \lfloor \text{leave}) - (\text{start} \circ \lceil \text{join})$



Who Attended Online User Meetings?

`watched ← (0.5 × end - start) (≤ 0 1) (end ∘.| leave) - (start ∘.| join)`



Who Attended Online User Meetings?

```
Attended ← {
  attendees ← α ◊ schedule ← ω
  Get ← {(1 ↓ α)[; α[1; ] i ≤ ω]}

  (join leave) ← Timestamp2Unix" attendees Get 'Join Time' 'Leave Time'
  (start end) ← Timestamp2Unix" schedule Get 'Start Time' 'End Time'

  watched ← (0.5 × end - start) (≤ 0 1) (end ◦. [ leave) - (start ◦. [ join)

  names ← attendees Get 'Attendee'
  names {v / ω} ⊔ Qwatched
}
```

