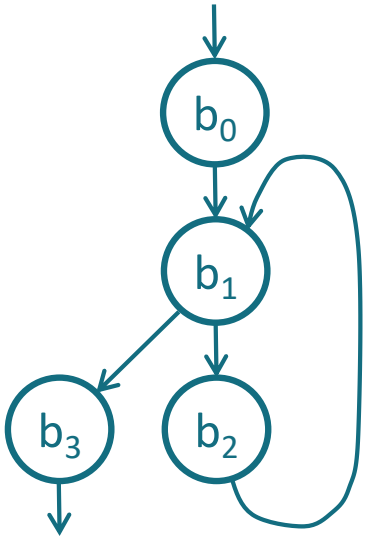
Branch prediction

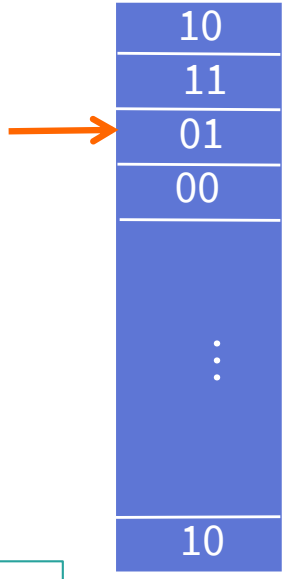
Impact of branch prediction on the execution times of basic blocks

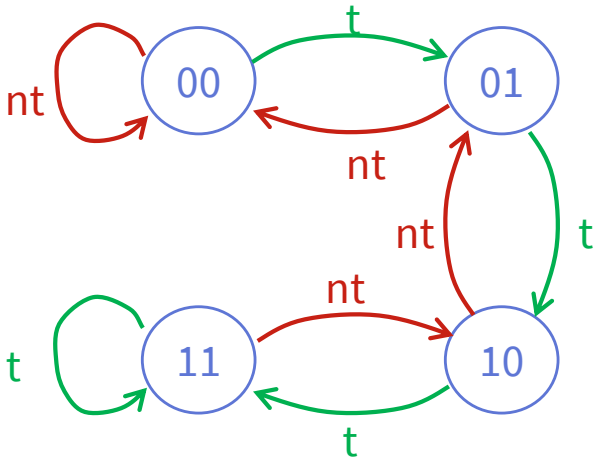
How is the direction predicted?

How is the target address predicted?



Branch History Table (BHT)





Branch Target Buffer (BTB)

Analysis of the predicted direction

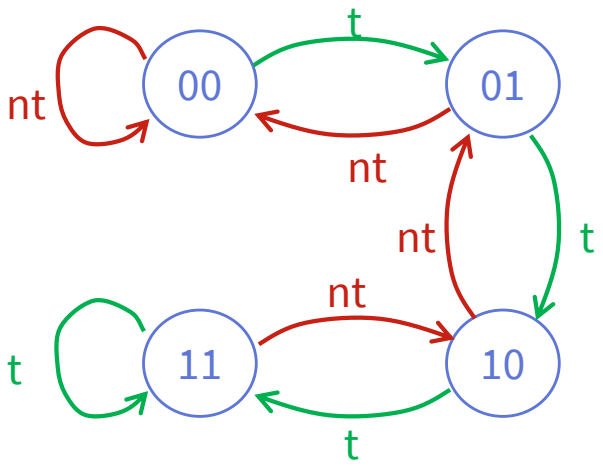
Semantics-based analysis

Pattern	Initial counter state			
	00	01	10	00
T^m				
N^m				
$(TN)^m$				
$(NT)^m$				
$(N^n T)^m$, n=2				
$(N^n T)^m$, n>2				
$(T^n N)^m$, n=2				
$(T^n N)^m$, n>2				

Analysis of the predicted direction

Semantics-based analysis

- $(TN)^m$ from state=01



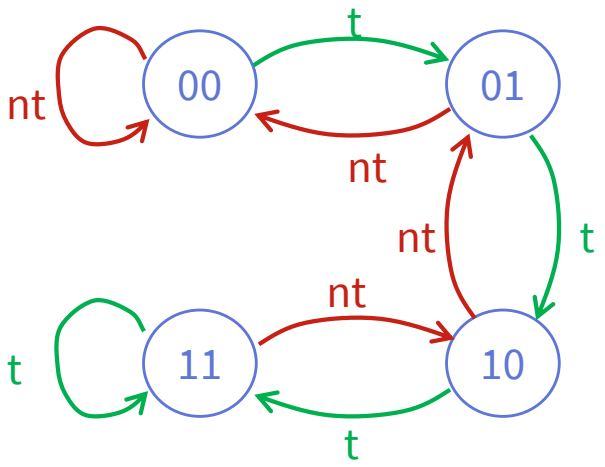

```
for (int i=0; i<m*2; i++)
   if (i%2 == 0)
      …
```

state	01							
predicted dir°								
actual dir°	T	N	T	N	T	N	T	N
mispred?								

Analysis of the predicted direction

Semantics-based analysis

- $(TN)^m$ from state=01




```
for (int i=0; i<m*2; i++)
   if (i%2 == 0)
      …
```

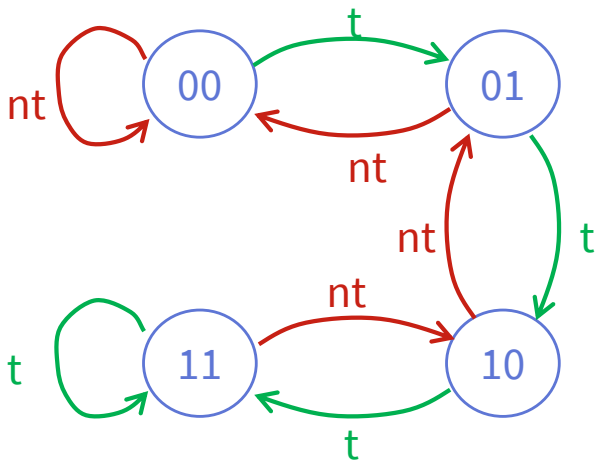
state	01	10	01	10	01	10	01	10
predicted dir°	N	T	N	T	N	T	N	T
actual dir°	T	N	T	N	T	N	T	N
mispred?	x	x	x	x	x	x	x	x

2m mispredictions

Analysis of the predicted direction

Semantics-based analysis

- $(N^nT)^m$ (n>2) from state=10




```
for (int i=0; i<m; i++)
    for (int j=0; j<n ; j++)
        …
```

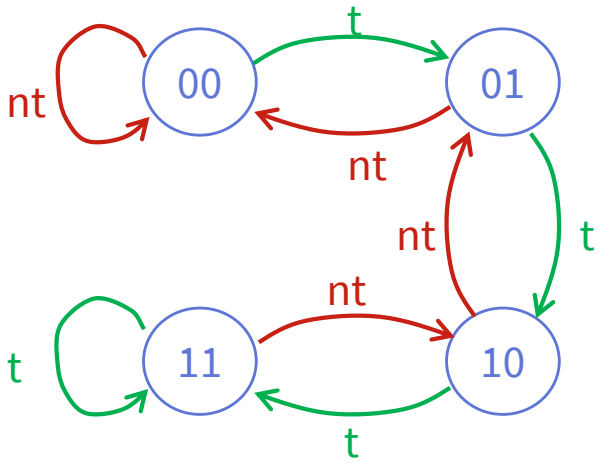
state	10									
predicted dir°										
actual dir°										
mispred?										

Analysis of the predicted direction

Semantics-based analysis

- $(N^nT)^m$ (n>2) from state=10

```
for (int i=0; i<m; i++)
    for (int j=0; j<n ; j++)
        …
```



state	10	01	00	00	00	01	00	00	00	00
predicted dir°	T	N	N	N	N	N	N	N	N	N
actual dir°	N	N	N	N	T	N	N	N	N	T
mispred?	x				x					x

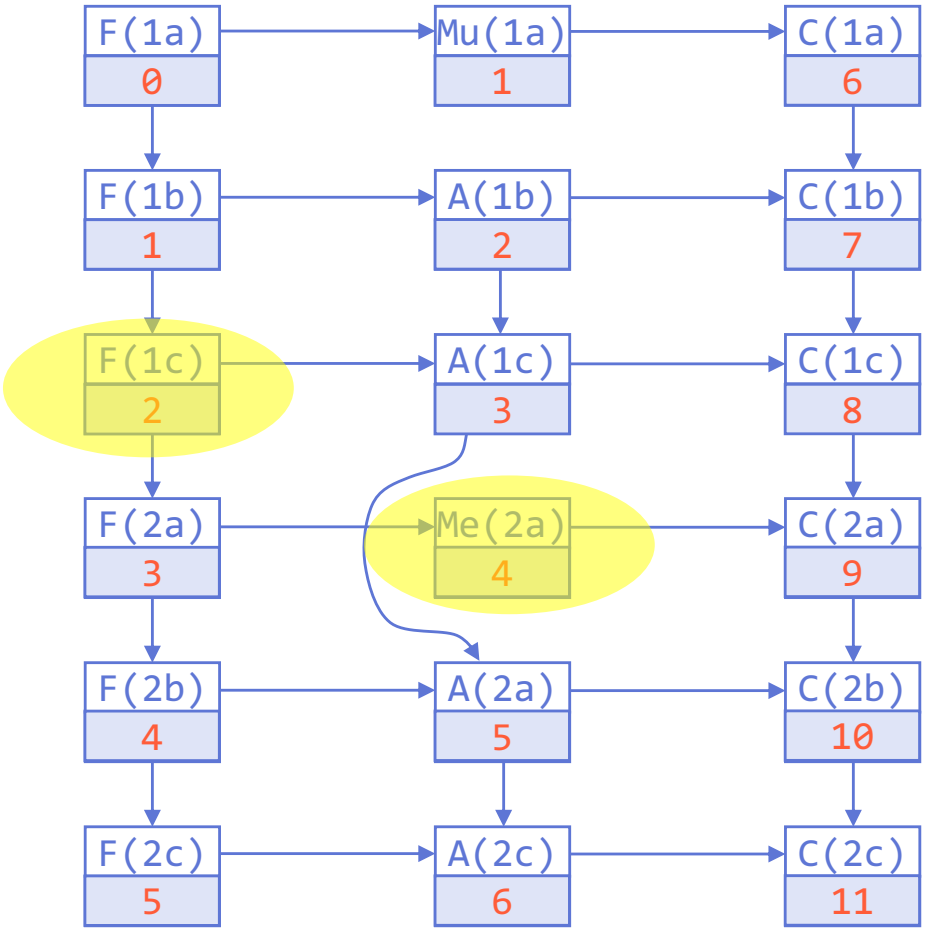
m+1 mispredictions

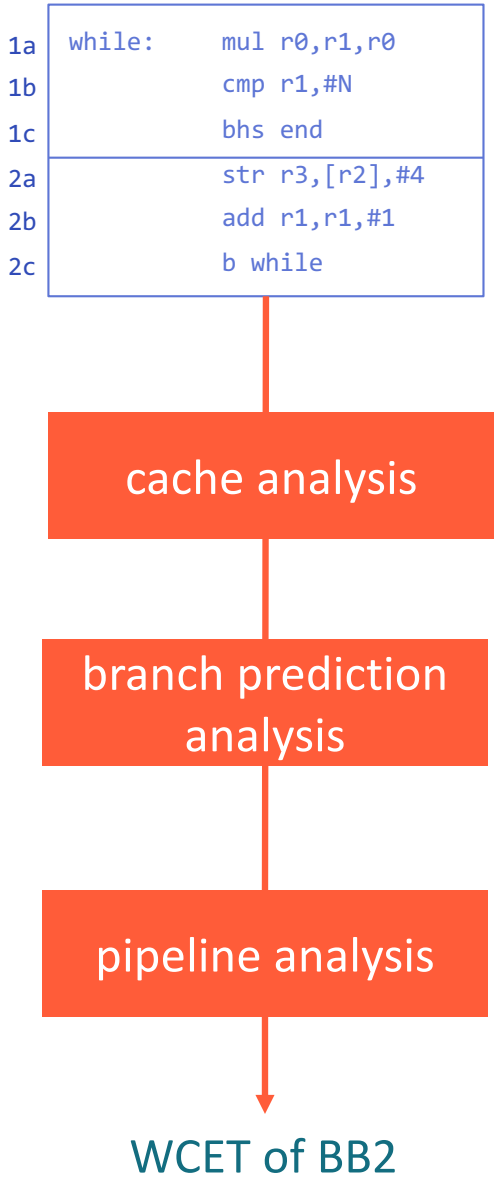
Analysis of the predicted direction

Semantics-based analysis

Pattern	Initial counter state			
	00	01	10	00
T^m	2	1	0	0
N^m	0	0	1	2
$(TN)^m$	m	2m	m	m
$(NT)^m$	m	m	2m	m
$(N^n T)^m$, n=2	m	m	1+m	3+m
$(N^n T)^m$, n>2	m	m	1+m	2+m
$(T^n N)^m$, n=2	3+m	1+m	m	m
$(T^n N)^m$, n>2	2+m	1+m	m	m

Summary…


F(1a)
0
Mu(1a)
1
C(1a)
6
F(1b)
1
A(1b)
2
C(1b)
7
F(1c)
2
A(1c)
3
C(1c)
8
F(2a)
3
Me(2a)
4
C(2a)
9
F(2b)
4
A(2a)
5
C(2b)
10
F(2c)
5
A(2c)
6
C(2c)
11


1a while: mul r0,r1,r0
1b cmp r1,#N
1c bhs end
2a str r3,[r2],#4
2b add r1,r1,#1
2c b while
cache analysis
branch prediction analysis
pipeline analysis
WCET of BB2