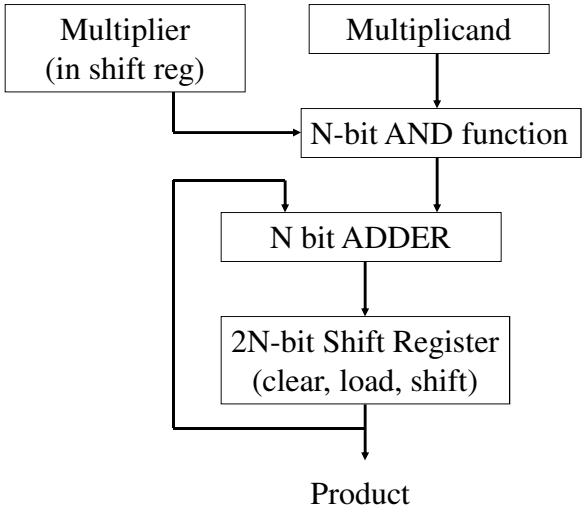
Working Up a High Speed Multiplier

Multiplication Algorithms

- Gradeschool Algorithm
- Modified Gradeschool Algorithm – A
- Modified Gradeschool Algorithm – B
- Booth's Algorithm
- High Speed Multiply Algorithm

Multiply: Gradeschool Algorithm

```
            10111001   (185)
          x 11010111   (215)
          ----------
            10111001
           10111001
          10111001
         00000000
        10111001
       00000000
      10111001
     10111001
    ----------------
    1001101101011111 (39775)
```



Start Condition

```
          10111001
        x 11010111
        ----------
          10111001
         10111001
        10111001
       00000000
      10111001
     00000000
    10111001
   10111001
----------------
0000000000000000
```

```
          10111001
        x 11010111
        ----------
          10111001



----------------
0000000000000000
```

```
  10111001
x 11010111
----------
```

```
  10111001
----------------
0000000000000000
```

```
  10111001
x 11010111
----------
```

```
  10111001
----------------
0000000010111001
```

```
  10111001
x 11010111
----------
```

```
  10111001
----------------
0000000010111001
```

```
  10111001
x 11010111
----------
```

```
  10111001
----------------
0000001000101011
```

```
  10111001
x 11010111
----------
```

```
      10111001
----------------
0000001000101011
```

```
  10111001
x 11010111
----------
```

```
      10111001
----------------
0000010100001111
```

```
  10111001
x 11010111
----------

     00000000
----------------
0000010100001111
```

```
  10111001
x 11010111
----------

    10111001
----------------
0000010100001111
```

```
  10111001
x 11010111
----------

   10111001
---------------
0001000010011111
```

```
  10111001
x 11010111
----------

   00000000
---------------
0001000010011111
```

```
  10111001
x 11010111
----------
```

```
  10111001
----------------
0011111011011111
```


```
  10111001
x 11010111
----------
```

```
  10111001
----------------
0011111011011111
```

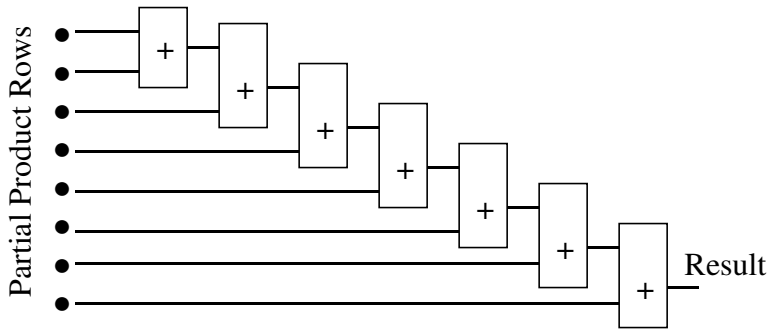
```
  10111001
x 11010111
----------
```

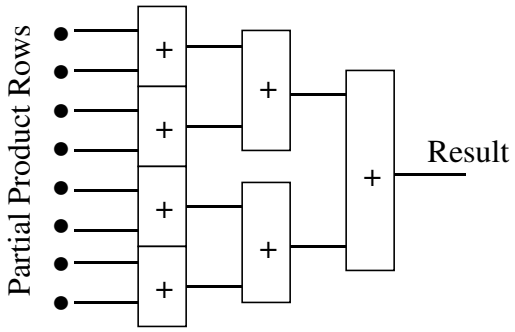
```
 10111001
----------------
0011111011011111
```

```
  10111001
x 11010111
----------
```

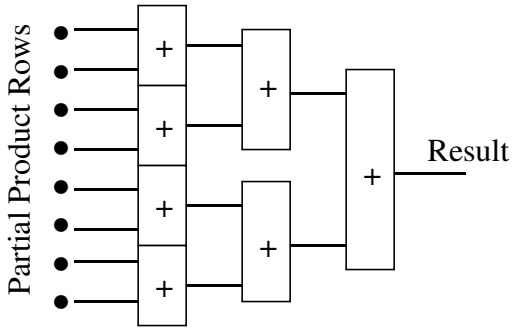
```
 10111001
----------------
1001101101011111
```

```
          10111001
        x 11010111
        ----------
          10111001→●
         10111001-→●
        10111001--→●
       00000000---→●
      10111001----→●
     00000000-----→●
    10111001------→●
   10111001-------→●
----------------
1001101101011111
```

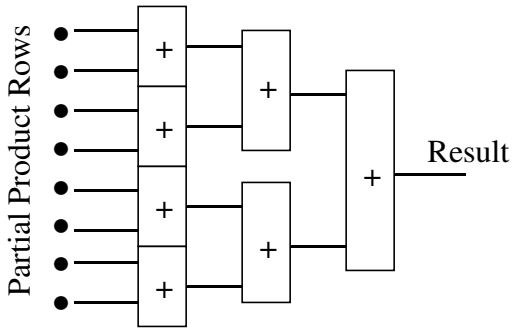




Let's do this one in VHDL

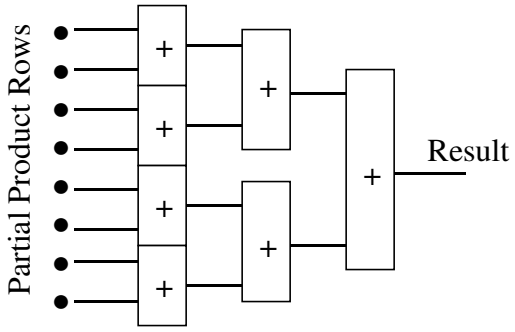


Let's do this one in VHDL



Step 1: Figure out data flow

Let's do this one in VHDL

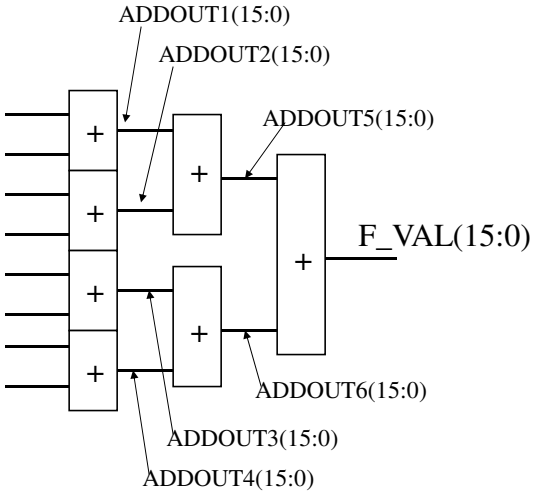


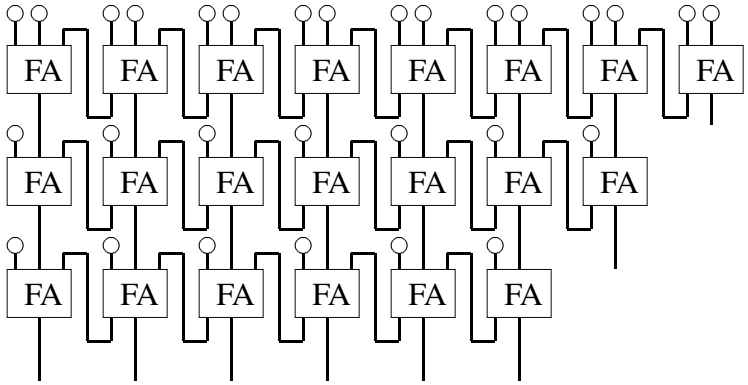
Step 1: Figure out data flow
Step 2: Name stuff….

Start with the Partial Product Array

PPA0(15:0)	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1
PPA1(15:0)	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	0
PPA2(15:0)	0	0	0	0	0	0	1	1	1	1	1	1	1	1	0	0
PPA3(15:0)	0	0	0	0	0	1	1	1	1	1	1	1	1	0	0	0
PPA4(15:0)	0	0	0	0	1	1	1	1	1	1	1	1	0	0	0	0
PPA5(15:0)	0	0	0	1	1	1	1	1	1	1	1	0	0	0	0	0
PPA6(15:0)	0	0	1	1	1	1	1	1	1	1	0	0	0	0	0	0
PPA7(15:0)	0	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0

More naming – the adder outputs




FA
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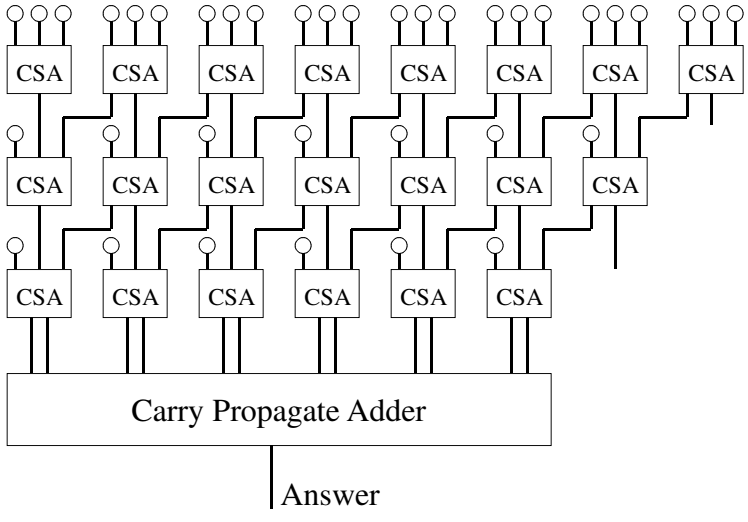
CSA
CSA
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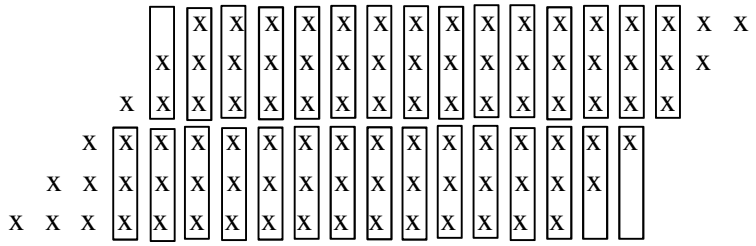
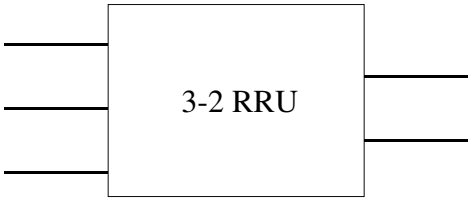
CSA
Carry Propagate Adder
Answer

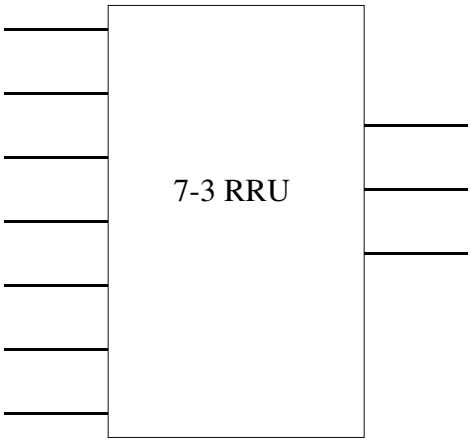


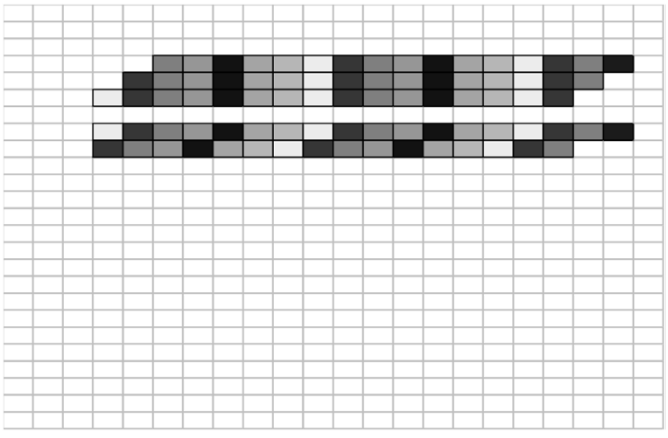
Carry-Save Adder:
Minimal Row Reduction Unit (RRU)
Input: 3 rows
Output: 2 rows

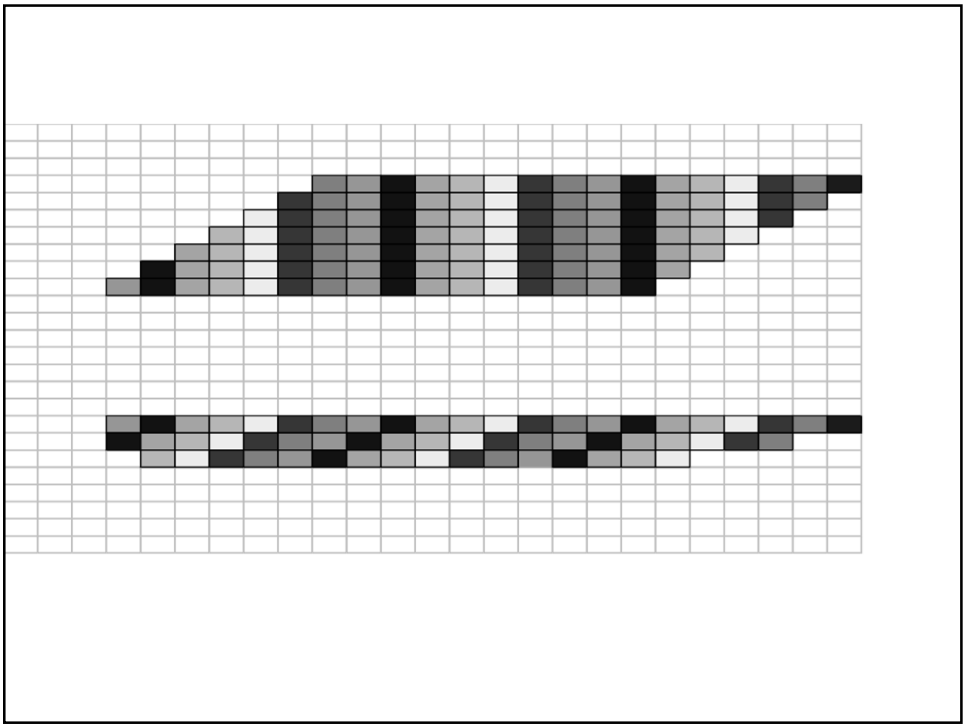


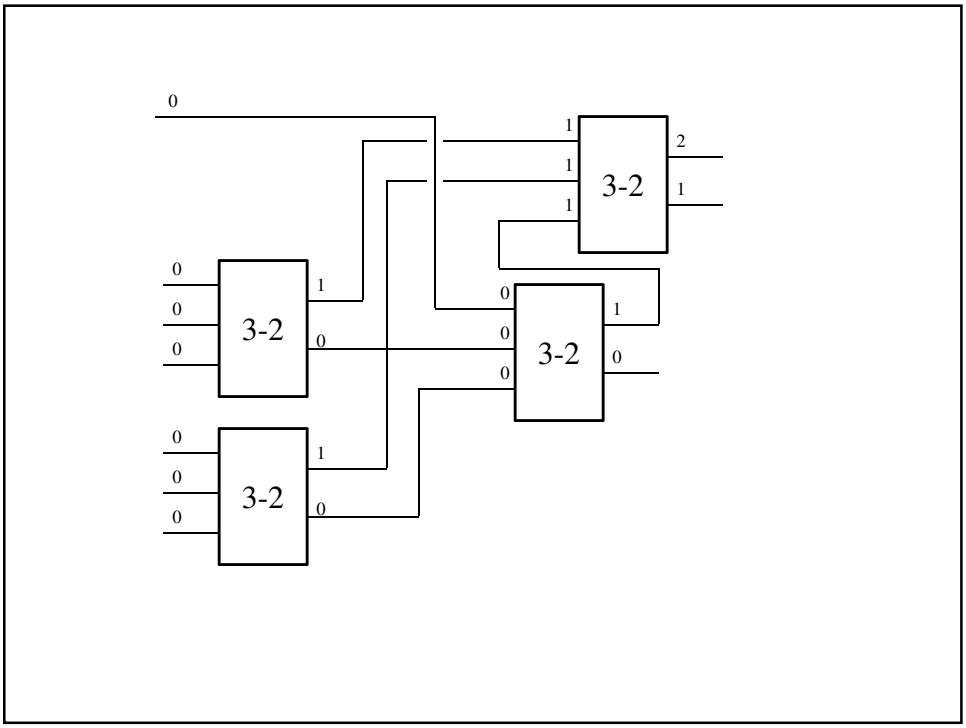
Note: Care must be taken to make sure that
the significance of the bits is handled properly

7-3 Row Reduction Unit
Input: 7 rows
Output: 3 rows








0
1
1
1
3-2
2
1
0
0
0
3-2
1
0
0
0
3-2
1
0
0
0
3-2
1
0
0
0
3-2
1
0

Row Reduction: any combination of 2^N-1 rows → N rows

2^N-1		N
3	→	2
7	→	3
15	→	4
31	→	5

Row Reduction System – 24 Bits