2024 Digital IC Design
Homework 4: Max-Priority Queue

NAME	黃偉峰
Student ID	E34106010

Simulation Result

Functional simulation	100	Gate-level simulation	100	Clock width	17 ns	Gate-level simulation time	P0:1269.271ns P1:1643.271ns P2:1779.271ns P3:2204.271ns

```
#  ****************************
#  **                        **
#  **  Congratulations !!    **
#  **                        **       |__||
#  **  Simulation PASS !!    **      / 0.0  |
#  **                        **    /_____   |
#  **  Your score =100       **   /^ ^ ^ \  |
#  **                        **  |^ ^ ^ ^ |w|
#  ****************************   \m___m__|_|
# ** Note: $finish    : C:/Users/kartg/Desktop/IC_v2/DIC_HW4/testfixture.v(158)
#    Time: 1259500 ps  Iteration: 0  Instance: /test
```

```
#  ****************************
#  **                        **
#  **  Congratulations !!    **
#  **                        **       |__||
#  **  Simulation PASS !!    **      / 0.0  |
#  **                        **    /_____   |
#  **  Your score =100       **   /^ ^ ^ \  |
#  **                        **  |^ ^ ^ ^ |w|
#  ****************************   \m___m__|_|
# ** Note: $finish    : C:/Users/kartg/Desktop/IC_v2/DIC_HW4/testfixture.v(158)
#    Time: 1269271 ps  Iteration: 0  Instance: /test
```

```
#  ****************************
#  **                        **
#  **  Congratulations !!    **
#  **                        **       |__||
#  **  Simulation PASS !!    **      / 0.0  |
#  **                        **    /_____   |
#  **  Your score =100       **   /^ ^ ^ \  |
#  **                        **  |^ ^ ^ ^ |w|
#  ****************************   \m___m__|_|
# ** Note: $finish    : C:/Users/kartg/Desktop/IC_v2/DIC_HW4/testfixture.v(158)
#    Time: 1633500 ps  Iteration: 0  Instance: /test
```

```
#  ****************************
#  **                        **
#  **  Congratulations !!    **
#  **                        **       |__||
#  **  Simulation PASS !!    **      / 0.0  |
#  **                        **    /_____   |
#  **  Your score =100       **   /^ ^ ^ \  |
#  **                        **  |^ ^ ^ ^ |w|
#  ****************************   \m___m__|_|
# ** Note: $finish    : C:/Users/kartg/Desktop/IC_v2/DIC_HW4/testfixture.v(158)
#    Time: 1643271 ps  Iteration: 0  Instance: /test
```

```
#  ****************************
#  **                        **
#  **  Congratulations !!    **
#  **                        **       |__||
#  **  Simulation PASS !!    **      / 0.0  |
#  **                        **    /_____   |
#  **  Your score =100       **   /^ ^ ^ \  |
#  **                        **  |^ ^ ^ ^ |w|
#  ****************************   \m___m__|_|
# ** Note: $finish    : C:/Users/kartg/Desktop/IC_v2/DIC_HW4/testfixture.v(158)
#    Time: 1769500 ps  Iteration: 0  Instance: /test
```

```
#  ****************************
#  **                        **
#  **  Congratulations !!    **
#  **                        **       |__||
#  **  Simulation PASS !!    **      / 0.0  |
#  **                        **    /_____   |
#  **  Your score =100       **   /^ ^ ^ \  |
#  **                        **  |^ ^ ^ ^ |w|
#  ****************************   \m___m__|_|
# ** Note: $finish    : C:/Users/kartg/Desktop/IC_v2/DIC_HW4/testfixture.v(158)
#    Time: 1779271 ps  Iteration: 0  Instance: /test
```

```
#  ****************************
#  **                        **
#  **  Congratulations !!    **
#  **                        **       |__||
#  **  Simulation PASS !!    **      / 0.0  |
#  **                        **    /_____   |
#  **  Your score =100       **   /^ ^ ^ \  |
#  **                        **  |^ ^ ^ ^ |w|
#  ****************************   \m___m__|_|
# ** Note: $finish    : C:/Users/kartg/Desktop/IC_v2/DIC_HW4/testfixture.v(158)
#    Time: 2194500 ps  Iteration: 0  Instance: /test
```

```
#  ****************************
#  **                        **
#  **  Congratulations !!    **
#  **                        **       |__||
#  **  Simulation PASS !!    **      / 0.0  |
#  **                        **    /_____   |
#  **  Your score =100       **   /^ ^ ^ \  |
#  **                        **  |^ ^ ^ ^ |w|
#  ****************************   \m___m__|_|
# ** Note: $finish    : C:/Users/kartg/Desktop/IC_v2/DIC_HW4/testfixture.v(158)
#    Time: 2204271 ps  Iteration: 0  Instance: /test
```

Synthesis Result

Total logic elements	761
Total memory bit	0
Embedded multiplier 9-bit element	0

Flow Status	Successful - Sun May 26 19:04:45 2024
Quartus Prime Version	20.1.1 Build 720 11/11/2020 SJ Lite Edition
Revision Name	MPQ
Top-level Entity Name	MPQ
Family	Cyclone IV E
Device	EP4CE55F23A7
Timing Models	Final
Total logic elements	761 / 55,856 (1 %)
Total registers	141
Total pins	50 / 325 (15 %)
Total virtual pins	0
Total memory bits	0 / 2,396,160 (0 %)
Embedded Multiplier 9-bit elements	0 / 308 (0 %)
Total PLLs	0 / 4 (0 %)

Description of your design
Idx register:此值代表正在處理的 element 在陣列中的位置。 Size register:為陣列中最後一個 valid element 所在的位置。 INPUT:直接將資料輸入進陣列中，輸入完再進行 Heapify，Heapify 我將其分成三個 state，HEAPIFY、EXCHANGE_WITH_LARGEST、NEXT_HEAPIFY，在 HEAPIFY 時將比較 left child 和 right child 哪個是較大的，EXCHANGE_WITH_LARGEST 時將現在的 idx 跟 largest 者進行交換，NEXT_HEAPIFY 判斷還有沒有下次 HEAPIFY。 EXTRACT_MAX:將最後的元素擺到第一個位置上，並將狀態接到 HEAPIFY 上。 INCREASE:一路往 parent 比較，若現在的 idx 較大則跟 parent 做交換。 WRITE:透過 WRITE_DELAY 來穩定確認資料有正確讀到後，下一個 state 接到 WRITE 上將 RAM_VALID 拉起進行輸出。

*Scoring = (Total logic elements + total memory bit + 9*embedded multiplier 9-bit element) × (Total cycle used*clock width)*