1. Calculation of communication cost

a) In a 2D-torus, original processor will use ring algorithm to send it information to the processors in its row. And then double the size of processors in column.

As for pop time, it should be $2(\sqrt{P}-1)$, and totally $\log_2 P*m$ byte message is sent. each processor need start up, but since each time dual processor is sending, the number of startup time should be $\log_2 P$(P is the number of processors).

The process can be: (s means source information)

Step 1:

	s			s	

Step 2:

s	s		s	s	

Step 3:

s	s	s	s	s	s

Step 4:

s	s	s	s	s	s
s	s	s	s	s	s

Step 5:

s	s	s	s	s	s
s	s	s	s	s	s
s	s	s	s	s	s
s	s	s	s	s	s

Step 6:

s	s	s	s	s	s
s	s	s	s	s	s
s	s	s	s	s	s
s	s	s	s	s	s
s	s	s	s	s	s
s	s	s	s	s	s

And since the broadcast is using cut-through routing, the total time is:

$$t = \log_2 P*t_s + \log_2 P*m*t_w + 2*(\sqrt{P}-1)*t_h$$

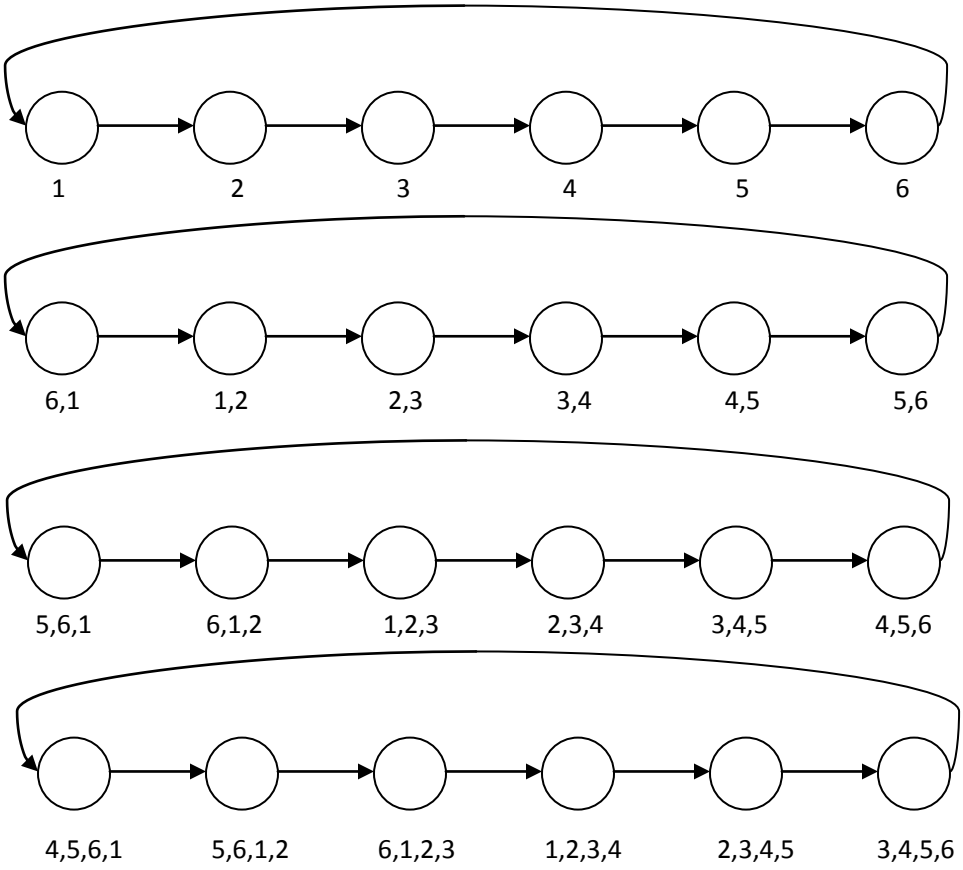
t = 6*10 + 6*1000*0.01 + 2*5*2 = 140microseconds

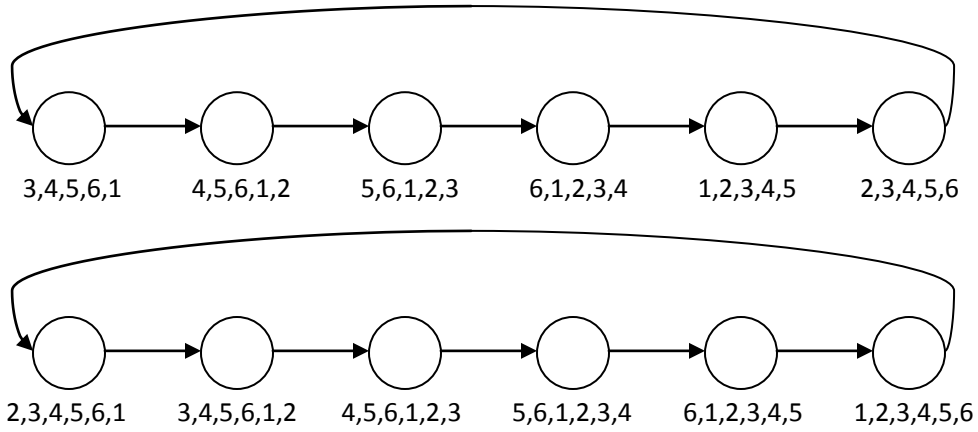
b) In a 2D-torus, all to all scatter's process is adapt ring algorithm in each row, then adapt the ring algorithm in each column.

To scatter all the information in a row, the time should be $\sqrt{\mathrm{P}}-1$(P is number of processors). And to scatter all the information in a column, the time is also $\sqrt{\mathrm{P}}-1$.

So the total pop time should be $2(\sqrt{\mathrm{P}}-1)$.

Just take one row as example, the process is(6 steps):





So is the process in the column.

Since CT routing does not provide any benefit over SF for scatter, the CT does not work actually.

Thus, the total time is:

$$t = 2(\sqrt{P} - 1)*t_s + (\sqrt{P} - 1)*P*m*t_w$$

$$t = 10*10 + 5*36*1000*0.01 = 1900 \text{ microseconds}$$