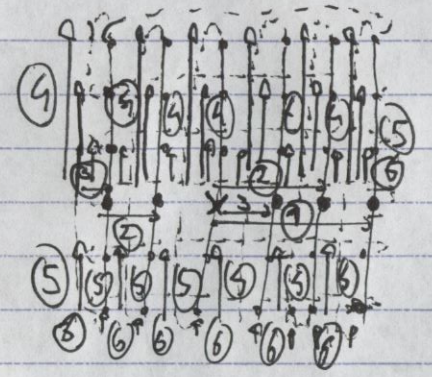
Part a).

one to all broadcast on a 6.6 2D Torus.



x is the (2,2) node

From the (2,2) it takes 6 steps to reach all the nodes

which is coherent with the

$2\log_2 6 \simeq 6$.

the steps are :

$$\left(\begin{array}{l} t_s + t_w.m + t_h \cdot \frac{\sqrt{p}}{2} \\ + \quad t_s + t_w.m + t_h \cdot \frac{\sqrt{p}}{4} \\ + \quad t_s + t_w.m + t_h \frac{\sqrt{p}}{6} \end{array} \right) \times 2$$

$$(=) \left(\sum_{i=1}^{\log_2(\sqrt{p})} t_s + t_w.m + t_h \left(\frac{\sqrt{p}}{2^i} \right) \right) \times 2$$

$$(=) \left(t_s \log_2(\sqrt{p}) + t_w.m.\log_2(\sqrt{p}) + t_h(\sqrt{p}-1) \right) 2.$$

$$(=) \; 2\log_2(\sqrt{p}) \left(t_s + t_w.m \right) + 2\, t_h(\sqrt{p}-1)$$

we know that $2\log_2(\sqrt{p}) = \log_2(p)$

thus

$$(=) \; \boxed{\log_2(p) \left(t_s + t_w.m \right) + 2\, t_h (\sqrt{p} - 1)}$$

with the given values:

$t_s = 10\,\mu s$
$t_h = 10\,\mu s$ and $m = 1000$ bytes.
$t_w = 0{,}2\,\mu s$

We can compute the cost as

$$\text{cost} = \log_2(36) \left(10 \times 2 \times 0.2 \cdot 1000 \right) + 2.2\,(5)$$
$$\text{cost} \simeq 4025{,}1699\,\mu s$$

or $\boxed{\text{cost} \simeq 4.025\ ms}$

b) All to all scatter.

All nodes are going to transfer 1000 bytes to all the other nodes thus there is going to be $2(\sqrt{p}-1)$ steps and $p.m$ data transmitted

the steps will be

$$\left(\begin{array}{l} 1)\ t_s + t_w.m(\sqrt{p}-1 \\ 2)\ t_s + t_w.m(\sqrt{p}-2 \\ 3)\ t_s + t_w.m(\sqrt{p}-3 \\ 4\ t_s + t_w.m(\sqrt{p}-4 \\ 5)\ t_s + t_w.m(\sqrt{p}-5 \end{array} \right) \times 2 \text{ steps}$$

$$(=) \left(\sum_{i=1}^{\sqrt{p}-1} t_s + t_w.m(\sqrt{p}-i) \right) \times 2$$

$$(=) \left(t_s(\sqrt{p}-1) + \sum_{i=1}^{\sqrt{p}-1} t_w.m.i \right) \times 2$$

~~$(=) \left((t_s(\sqrt{p}-1) + \frac{1}{2} t_w.m.p \right) \times 2$~~

$$(=) \left((t_s(\sqrt{p}-1) + \frac{1}{2} t_w.m.p(\sqrt{p}-1)) \right) \times 2$$

$(=)\ (\sqrt{p}-1)(2t_s + t_{w.m.p})$

with the given values

With $t_s = 10\ \mu s$

$t_w = 0.2\ \mu s$ and $m = 1000$

$Cost = (35)\ [20 + 0.2 \times 1000.36)$

$Cost = 252\ 700\ \mu s$

n in ms

$\boxed{Cost = 225,7\ ms}$ to transmit 36 ko.