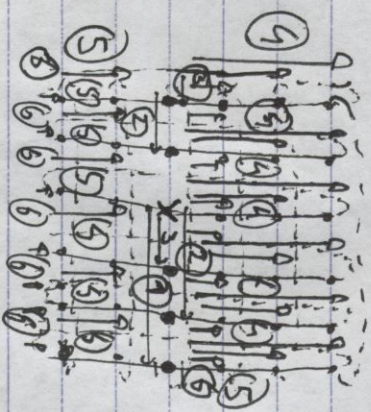**Part a).**

on to all nodes x in 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

$$2\log_2 6 \approx 6.$$

the steps are :

$$\left(3 + tw.m + th \cdot \frac{\sqrt{p}}{2} \right.$$

$$+ \; ts + tw.m + th \cdot \frac{\sqrt{p}}{4}$$

$$\left. + \; ts + tw.m + th \cdot \frac{\sqrt{p}}{6} \right) \times 2$$

$$(=) \; \left(\sum_{i=1}^{\log_2(\sqrt{p})} ts + tw.m + th \left(\frac{\sqrt{p} - m}{2^i} \right) \right) \times 2$$

$$(=) \; \left(ts \log_2(\sqrt{p}) + tw.m \cdot \log_2(\sqrt{p}) + th(\sqrt{p}-1) \right) 2$$

$$(=) \; 2\log_2(\sqrt{p}) \left(ts + tw.m \right) + 2 \, th(\sqrt{p}-1)$$

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

Thus

$$\boxed{\log_2(p)\,(ts + tw.m) + 2\,th\,(\sqrt{p}-1)}$$

with the given values.

$$ts = 10\ \mu s \qquad \text{and} \quad m = 1000 \text{ bytes}$$
$$th = 10\ \mu s$$
$$th = 0.2\ \mu s$$

We can compute the cost as

$$cost = \log_2(36)(10 \times 1 \times 0.2 \cdot 1000) \cdot 3.2\,(s)$$
$$cost \approx 4025.1633\ \mu s$$

$$\boxed{cost \approx 4.025\ ms}$$

b) All to all scatter.

All nodes are going to transfer 1000 bytes to all the other nodes, thus there is going to be $\log_2(\sqrt{p}-1)$ steps and $t.m$ data transmitted

the steps will be

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

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

$$(=) \; \left(ts(\sqrt{p}-1) + \sum_{i=1}^{\sqrt{p}-1} tw.m \cdot i \right) \times 2$$

$$(=) \; \left(ts(\sqrt{p}-1) + \frac{tw.m \cdot p}{2} \right) \times 2$$

$$(=) \; \left(ts(\sqrt{p}-1) + \frac{1}{2} tw.m \cdot p(\sqrt{p}-1) \right) \times 2$$

$$(=) \; \left((ts(\sqrt{p}-1) + \frac{1}{2} tw.m.p(\sqrt{p}-1)) \right) \times 2$$

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

With the given values

With $t_s = 10 \, \mu s$

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

$C_{at} = (35) \, (20 + 0.2 \times 1000.36)$

$C_{at} = 25700 \, \mu s$

n in ms

$\boxed{C_{at} = 215.7 \, ms}$ to transmit 36 to.