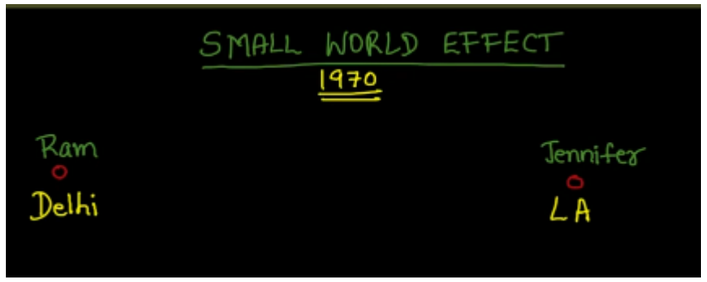
Week-11: **The Small World Effect**

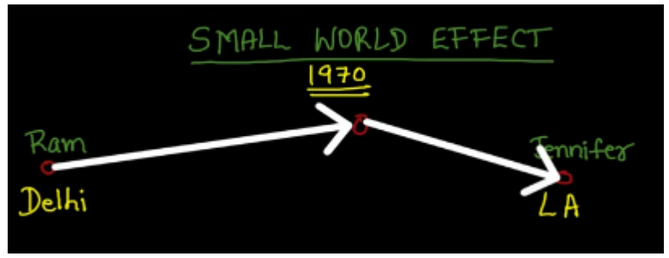
--- on 12th October, 2021 ~ Wednesday_2

Module-01: **Introduction**

!There's a person named **Ram** in the city of Delhi, and would need to contact **Jennifer** who is in Los Angelas (LA) for some business requirement --- say, its in the back 1970s, at which there is no existance of Internet.

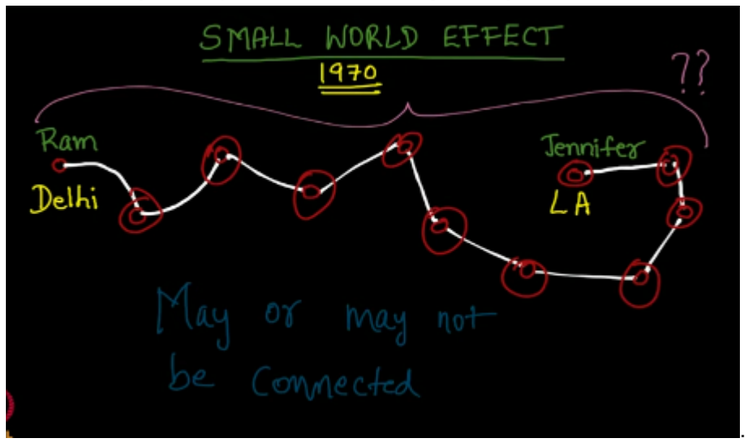


-- Now, how would he contact her..??. An Idea would be like..



-- contact via someone who knows Jennifer.

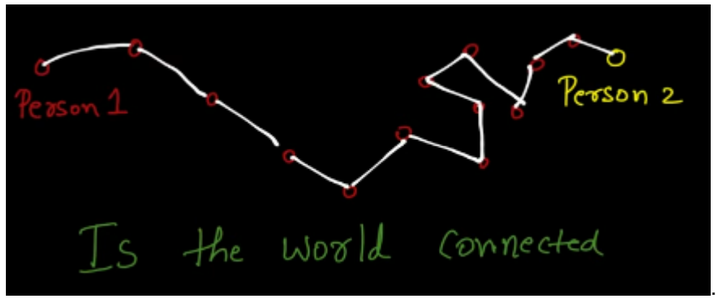
But, how likely is this possible....?? -- it may or may not exist..but.but....

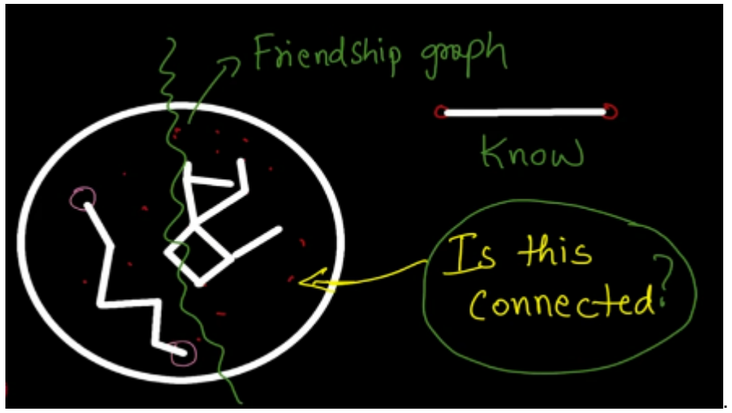


. Ram knows someone, who knows someone, they knows someone..... they in-turn knows Jennier. -- This too, may or may not. Are they even connected..?? May or may not.,....

Now, let's try an experiment, is the world connected..???i.e,. meant as...

Let's take two people from two different people. Person-1, knows someone, they knows someone....they.... at end they reach at person-2.



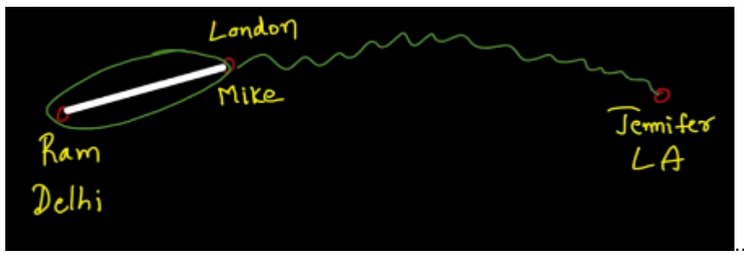
. In terms of graph theory and took the whole earth, 

. You put an edge b/w any two chosen random people, if they are connected,

- Nowm if the whole world is connected, then there exists a path between any two chosen nodes.
- If not (i.e.,if broken..), then not.

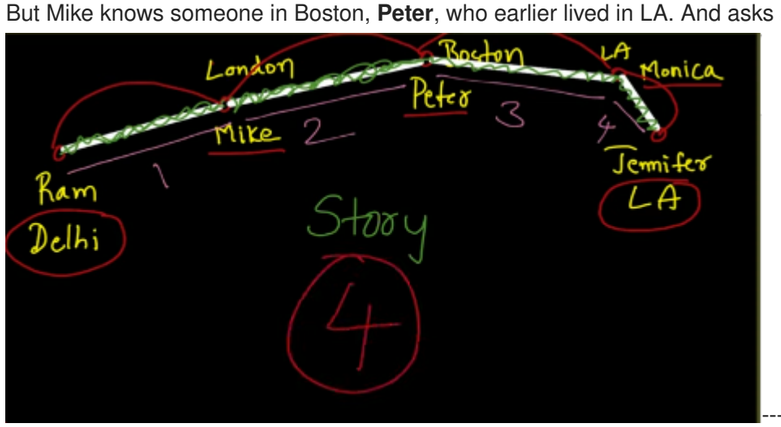
Let us re-visit the first example...

- Say, Ram has a friend in London, named Mike. And asks **Hello Mike, do you know *Jennifer* in LA?**



... **NOTE**, here too, still Ram is not sure that, he knows Jennifer*, but, still would like to explore the path/chance .

- But Mike knows someone in Boston, **Peter**, who earlier lived in LA. And asks about the contact. But they too don't. They knows **Monica**, hwo is a close friend of **Jennifer**, and contact finishes.



--- it happened in 4 hops. --- but note that its a story.

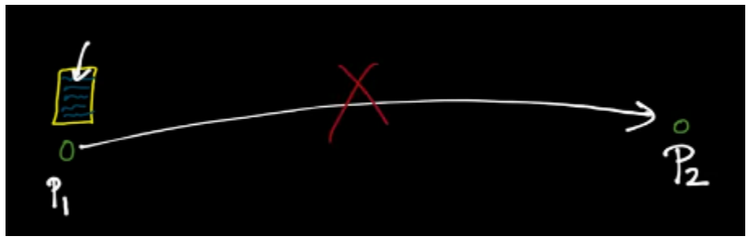
Here goes the question..**Is the friendship-network connected..?? If yes, what's the distance between them?**

Module-02: **Milgram's Experiment**

-- conducted in the year of 1967

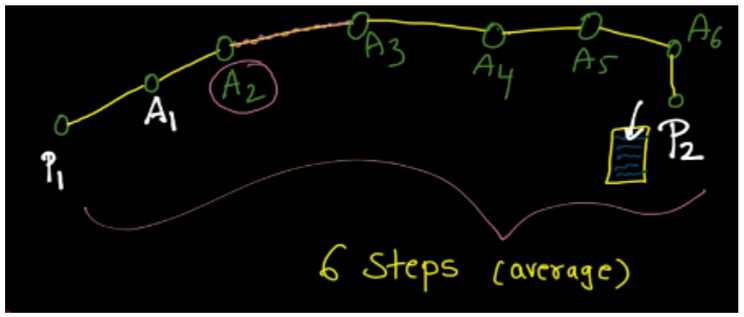
How the experiment was conducted..? (with the following rules)

1. Chosen two people individually (uniformly at random), and they don't know each other. The one in those given a letter, and need to post to other.
2. The address is mentioned on the letter, but shouldn't post it directly.



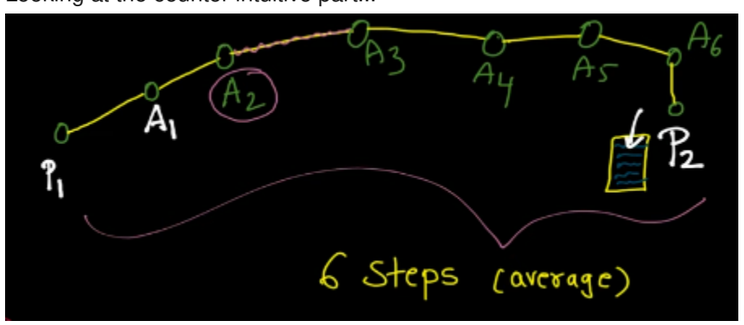
then how the letter reaches the other person..??

Should pass to someone he knows and suspects that, they know **P2**. -- ***NOTE**, the cases of not being transmitted and going in reverse direction are low, because, they are sent to the person who atleast know her or close to her place.*



-- happened in 6 hops (on avg). And published this in the article **Psychology Today**.

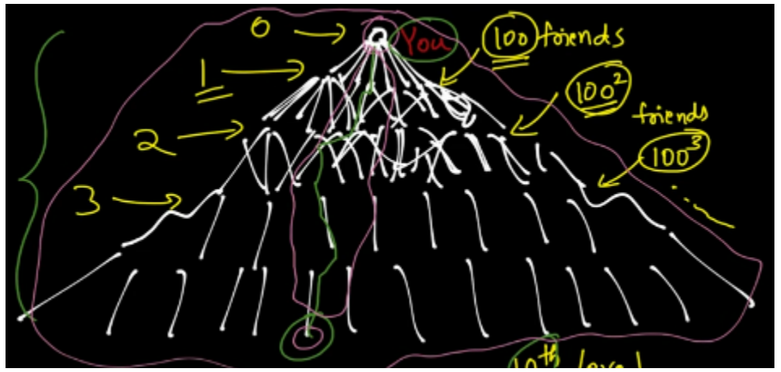
Looking at the counter-intuitive part...



Big(in-terms o fbig population). Small (as separated by 6 people)

But its not so counter-intuitve...

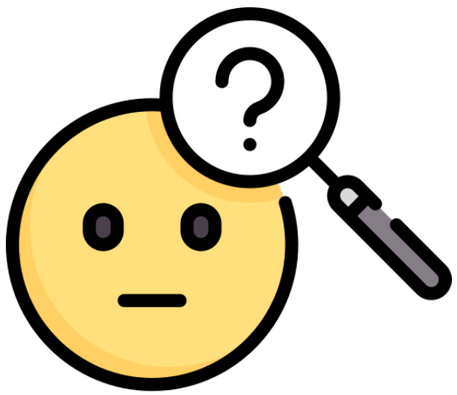
- (Say) You had 100 friends, they in-turn had 100 friends, they in-turn had 100 friends.....



Module-03: **The Reason**

--- the same experiment was **re**-conducted by **Watts** and **Strogatz** in the year of 1998 on the e-mail networks.

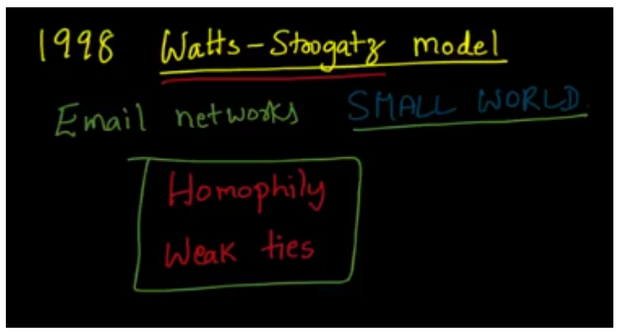
- Its popularly called as **Watts-Strogatz Model** and observed the *Small world phenomena*.



How they re-conducted, and observed the phenomena..??

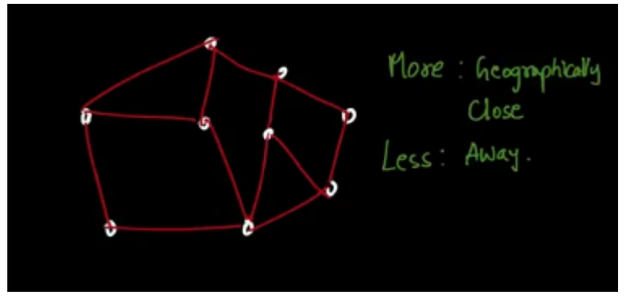
Look ahead..

How could they observe the *Small world phenomena....??* via the following two reasons..



They said... in a given network of nodes with some edges.. ie., let's have a look at each of the above ..

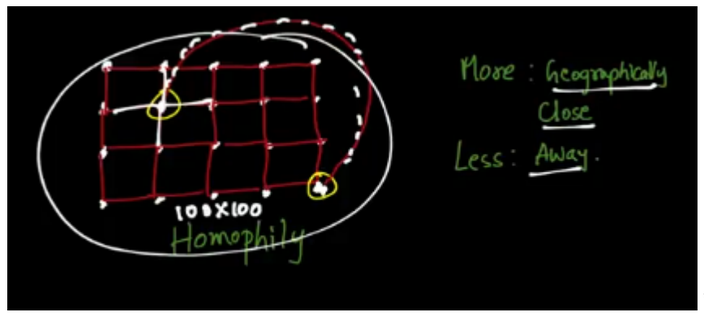
- The are like the grid..i.e.,



Assume it as your locality, and you'll have **more** friends around your locality and less friends are out of locality.

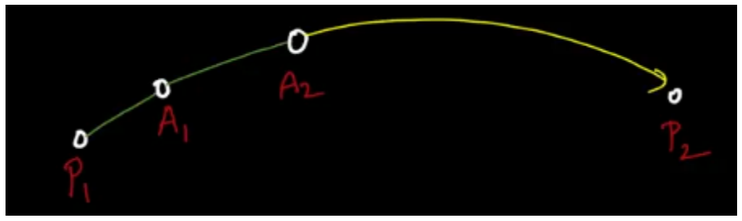
Let's model into a grid...Nodes being friends/houses and edges are the connected lines

Here, say the two friends are of differently-located (that's about the curvy-line b/w two circled nodes) -- Imagine for 100x 100 grid(i.e., extend to a large network).



You have more friends in your locality and less out of locality.

- Proposed as....

> **Because of *Homophily* and the *Weak ties*, in a grid like above, you tend to make mor friends near you and some out of it** -- this is what leading to small world phenomena. -- i.e.,
>
> 
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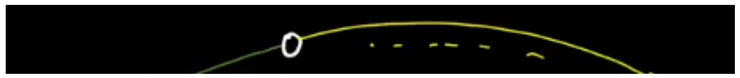
> -- In the example of Letter passing..

- P_1 need to pass the letter to P_2. As can't pass directly, gives to A_1 who is very close (say), he in-turn gives to A_2, who is not close to A_1, but close to $P-2$, and the letter lands near P_2.
  ..... Read once to get the insight.

Speaking it generically.. Consider multiple regions, and one needs to send a letter to another..

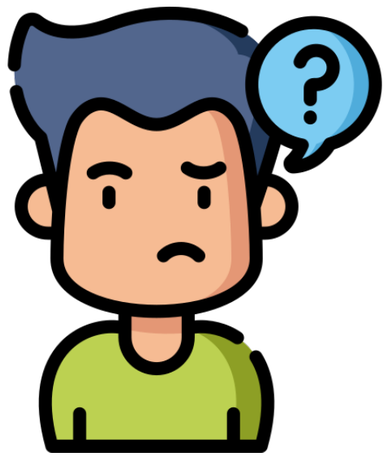
- If other person happens to be in the same region, it happens instantly -- as connected in multiple ways.
- If it happens to be the person in other region, then...
  - Any one of the person in the sender region would know the another person in another region. That person to another region.. finally lands near P_2.



so, Homophily(friends like them) coupled with Weak ties results in such phenomena.

Is this true...?? ..

> Yes, some networks really forms clusters like these and behaves as described above.



How..?? How..??

> Assume you had some friends close to you (these form a territory/cluster/region), as well as youi'll have some friends who are not close to your locality. These **outside-network connections (weak-ties) and the territorial connections (homophily) make the world connected**.
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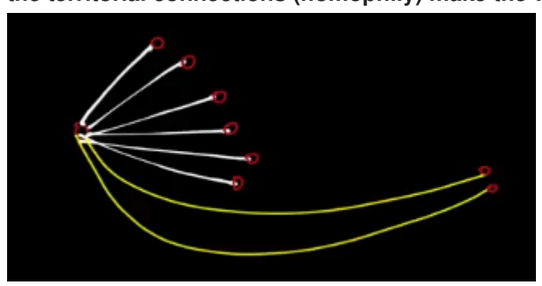
>  -- think for a while, it makes a sense....

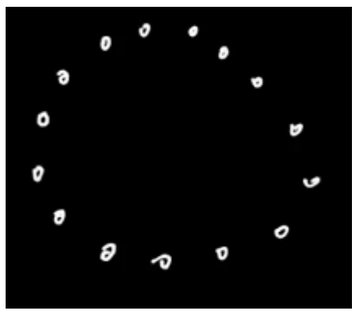
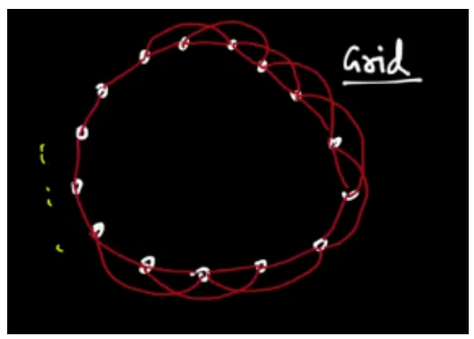
Module-04: **The Generative Model**

Hypothesis: Something is proposed as true, but no proper complete scientific evidence.

The observed small world phenomena, ..

- Weak ties and Homophily could be the reason for happening this.

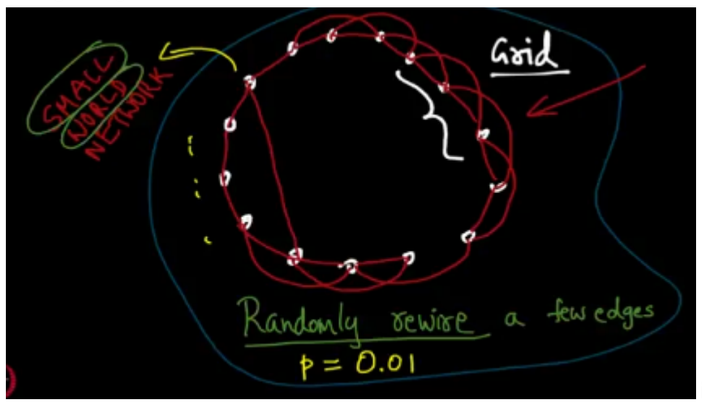
Now they gives a **Generative Model** -- i.e., a method to construct the graphs with the property having *Small world properties*.
Their proposal was...

1. Put the nodes in a circle like form. 
2. Start drawing the edges to their nearest edges. 

(In this example....say every body is friend to next friend) --------its very much similar to the grid....

What they proposed is....
Randomly re-wire a few edges. -- i.e., take some edge, and place it between some other nodes, randomly. With some probablity p.

Doing so.. gives the ..



i.e., Any two nodes are in-fact close to each other.

So, that's the motivation fo rthis.. **Why the world is big yet so small**