Mar 1, 2012

EE 597
Lecture 15

Bianchi's analysis for IEEE 802.11 DCF Saturation Throughput

- Markov Chain for a transmitter given W_0, m ← # of stages

  W_0: max contention window at first stage

- $\sum_{i=0}^{m-1} \pi_{i,0}$ = Prob. of transmission $= \tau$ — ①

p is the prob. of collision

by solving for the steady state distribution

- $\underbrace{(1-\tau)^{n-1}}_{\text{Prob. no one else transmits}} = \underbrace{1-p}_{\text{success prob conditioned on this transmitter being active}}$ — ②

~~assumption~~ / approximation independence

Prob. of succ = $\underbrace{\text{Prob succ} \mid \text{transmission}}$ · Prob of transm.

$$\cancel{\tau}(1-\tau)^{n-1} = (1-p)\cdot\cancel{\tau}$$

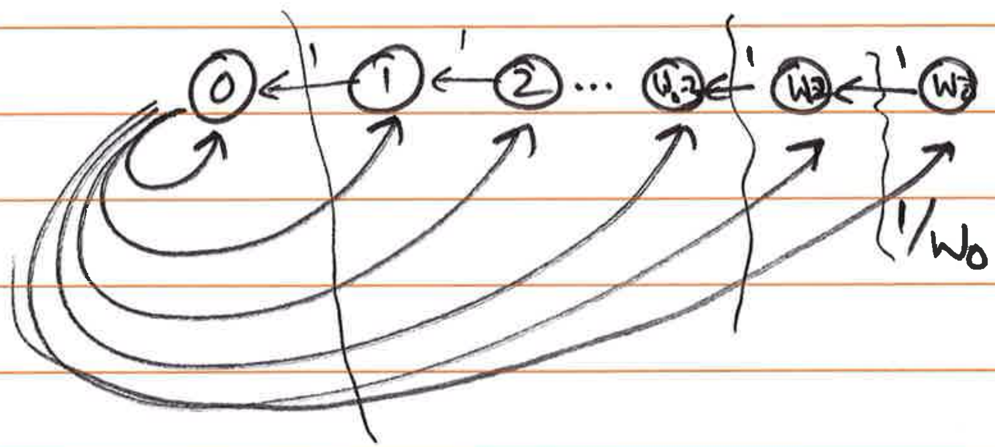
Eq (1) & (2)

- This yields a particular p for the given network size n, i.e a particular τ.

- Approximating by p-CSMA:

Throughput for one sender $= \dfrac{\tau(1-\tau)^{n-1} T_s}{(1-\tau)^{n-1}\sigma + n\tau(1-\tau)^{n-1} T_s + \left(1-(1-\tau)^{n-1} - n\tau(1-\tau)^{n-1}\right) T_c}$

simple example $\quad m = 1$



$$\frac{1}{W_0}\cdot \pi_0 = \pi_{W_0-1}$$

$$\frac{2}{W_0}\pi_0 = \pi_{W_0-2}$$

$$\vdots$$

$$\frac{W_0-1}{W_0}\pi_0 = \pi_1$$

$$\sum \pi_i = 1 \Rightarrow \pi_0 \sum_{i=1}^{W_0} \frac{i}{W_0} = 1$$

$$\tau = \pi_0 = \frac{W_0}{\sum_{i=1}^{W_0} i} = \frac{\cancel{W_0}}{\frac{\cancel{W_0}(W_0+1)}{2}} = \frac{2}{W_0+1}$$

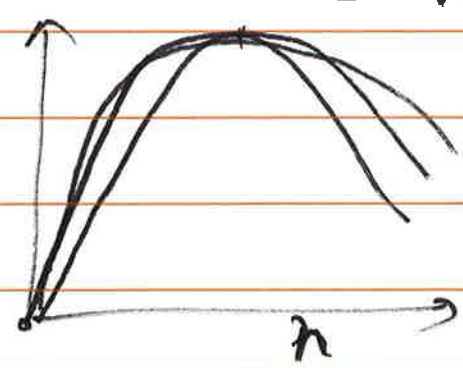
In this model,
for a given W_0, m, n,
we find a particular
throughput

Throughput $= f(W_0, m, n)$

if n is fixed, how do you
max. the throughput?
- vary W_0, m

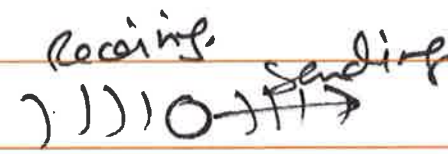
~~Farco~~ for p-CSMA

Throughput $= f(\tau, n)$ ← vary τ.



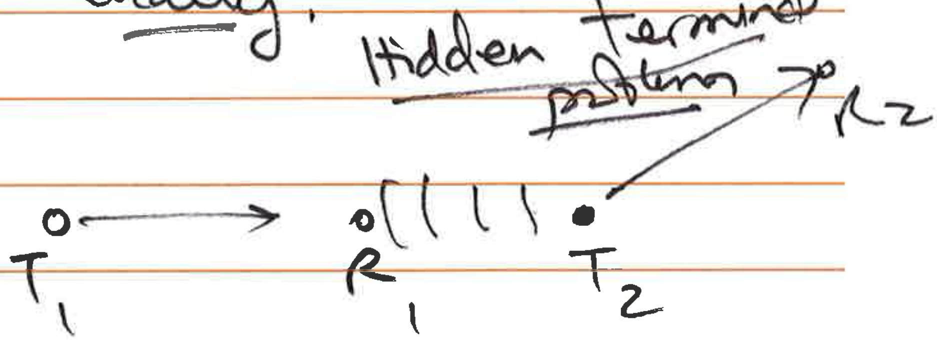
RTS - CTS

Wireless links are typically half-duplex



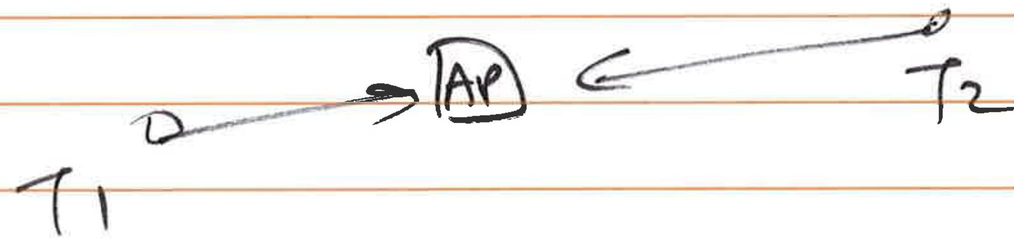
· makes it hard to detect collisions early

CSMA means that the transmitter only sends when channel is clear locally.



The possible interference condition at the receiver may go undetected.

∴ can still have collisions.



Virtual carrier sensing at the receiver is needed

↳ a simple handshake mechanism for transmitter to check w/ the receiver its availability.

RTS – Request to Send
CTS – Clear to Send.

typically small pkts (few Bytes)
less prone to collision

Typically RTS-CTS is only used for heavy traffic & large pkt size conditions

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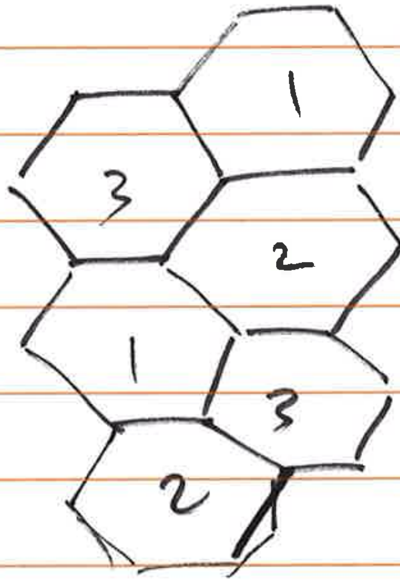
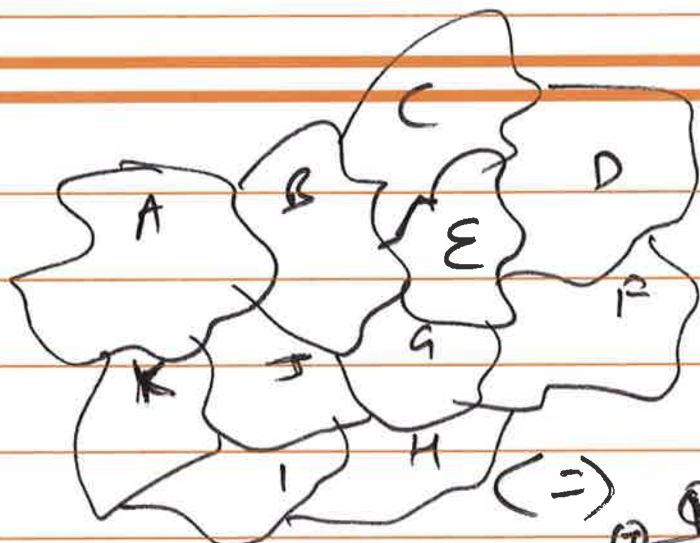
Medium Access & Resource Allocation
- Power Control
- Random Access
- * Channel Allocation

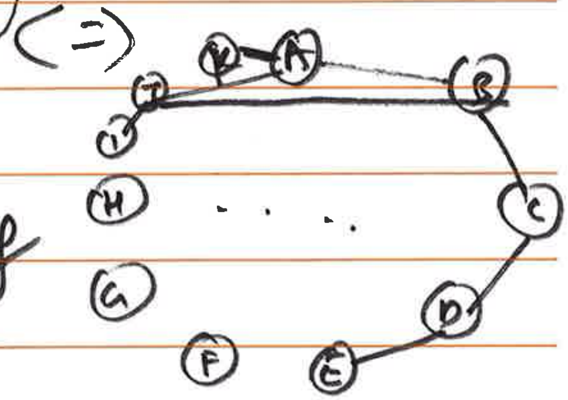
IEEE 802.11 PCF

point coordination function

centralized coordination of users.







Graph Coloring

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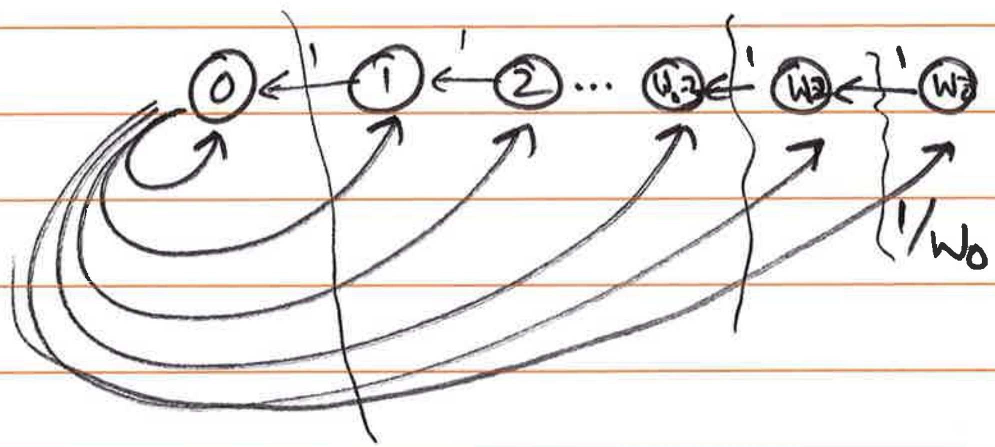

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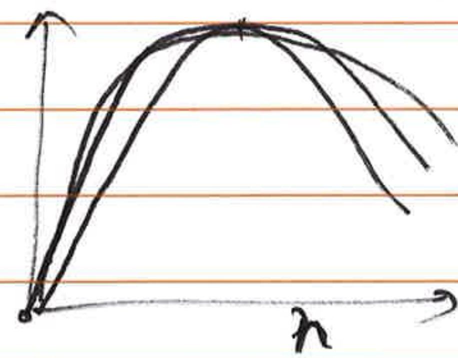

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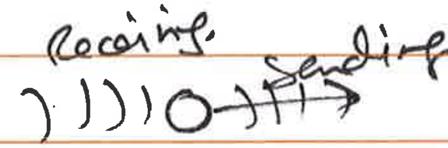

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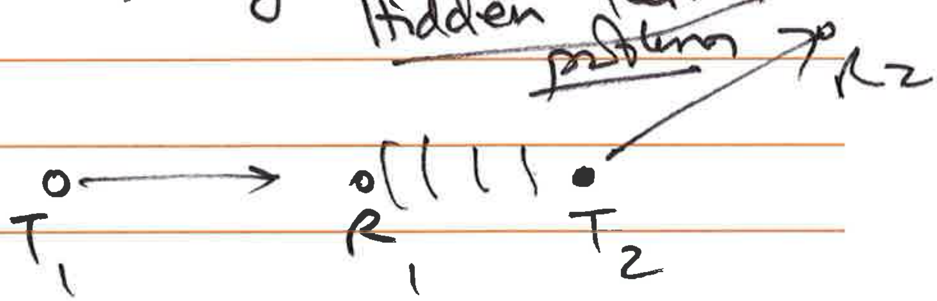
Hidden terminal problem



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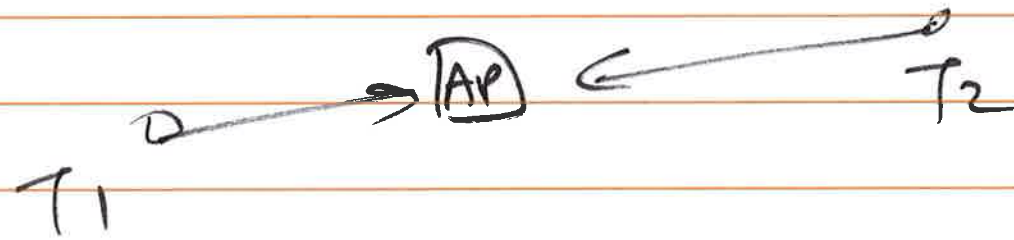

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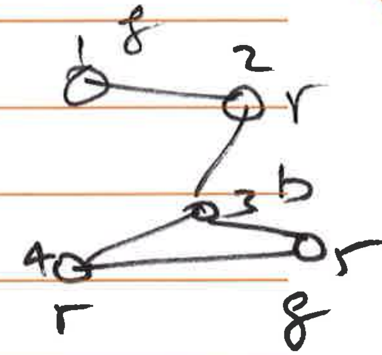
$G = (V, E)$

V: vertex set

E: edges



(vertex)

Graph Coloring: Allocate a color to each vertex such that neighboring vertices do not share the same color.

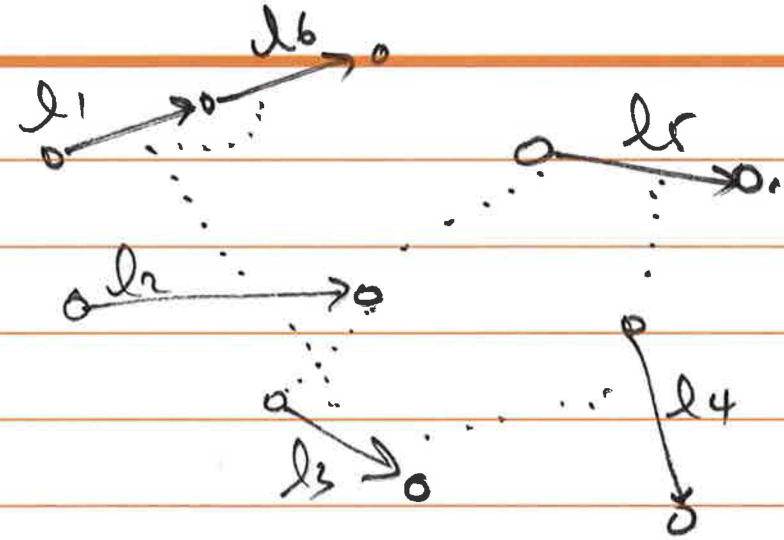
Want to minimize the # of colors.

$$V = \{\overset{r}{1}, \overset{g}{2}, \overset{b}{3}, \overset{y}{4}, \overset{k}{5}\}$$

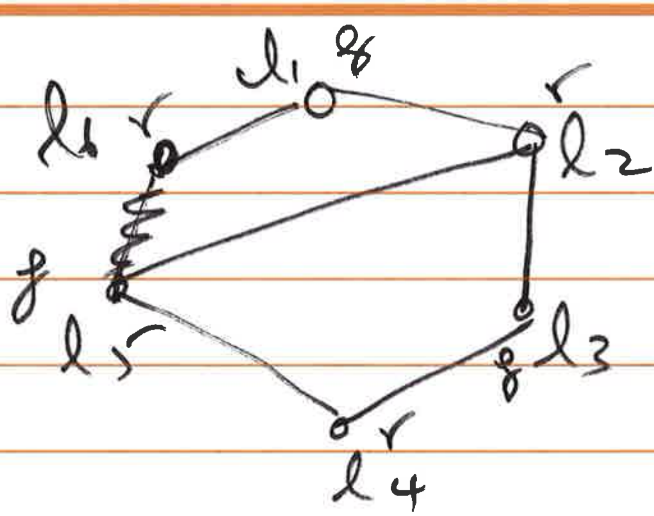
$$E = \{(1,2), (3,4), (2,3), (3,5), (4,5)\}$$

$$A \quad \begin{array}{c|ccccc} & 1 & 2 & 3 & 4 & 5 \\ \hline 1 & 0 & 1 & & 0 & \\ 2 & & 0 & 1 & & \\ 3 & & & 0 & 1 & 1 \\ 4 & 0 & & 1 & 0 & 1 \\ 5 & & & 1 & 1 & 0 \end{array}$$

Another example



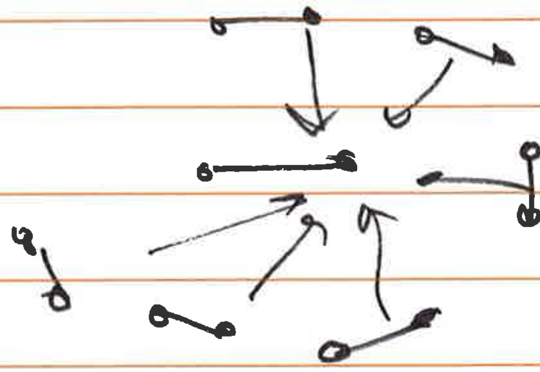
Pairwise interference relationships between distributed links yield a "conflict graph"



doing a coloring on this yields a TDMA / FDMA schedule.

In case of TDMA, a minimal coloring corresponds to higher throughput

$$\underbrace{\begin{array}{|c|c|} l_2 & l_1 \\ l_4 & l_3 \\ l_6 & l_5 \end{array}}_{\text{frame}} \begin{array}{c|c|} l_2 & l_1 \\ l_4 & l_3 \\ l_6 & l_5 \end{array} \; \cdots$$



additive
interference
may be
too
high,
even if
pairwise
constraints
are ok

$\chi(G)$ – chromatic # of graph
(min # of colors for
vertex coloring).

$\omega(G)$ – clique # of the graph
(largest no. of nodes
in the graph that
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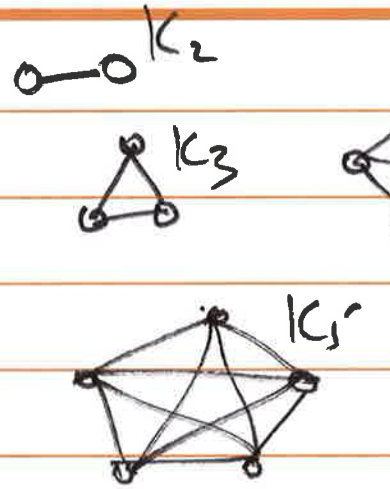
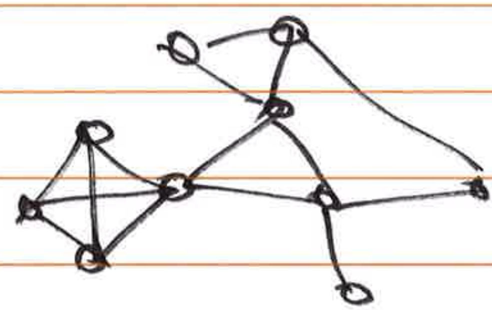


$\Delta_{max}(G)$ – the largest degree
of the graph
(no. of nbrs of the
vertex/node w/ most neighbors)

$\omega(G) \leq \chi(G) \leq \Delta_{max}(G) + 1$



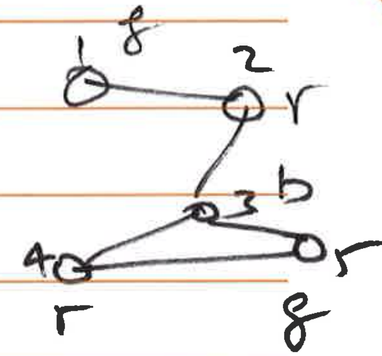
Greedy Vertex coloring heuristic algorithm is used to prove the upper-bound.

Graph Coloring is an NP-hard problem

Note: exam on thursday, in class 3/8

$G = (V, E)$

vertex set — V; edges — E



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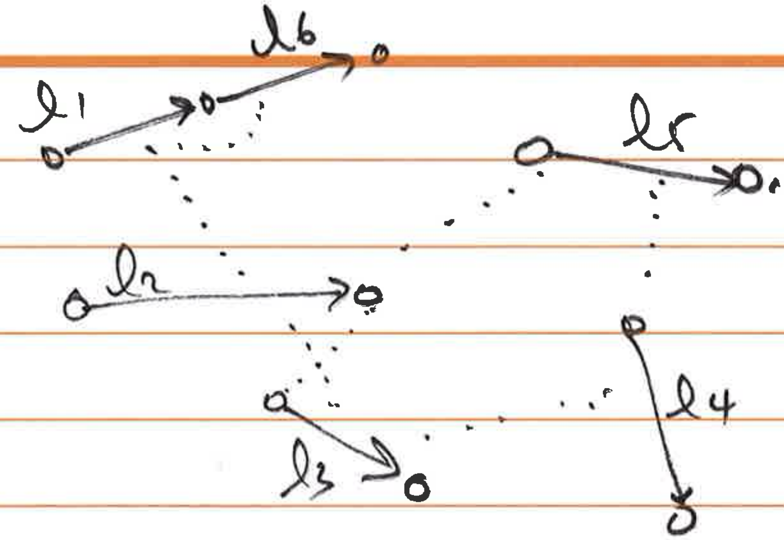

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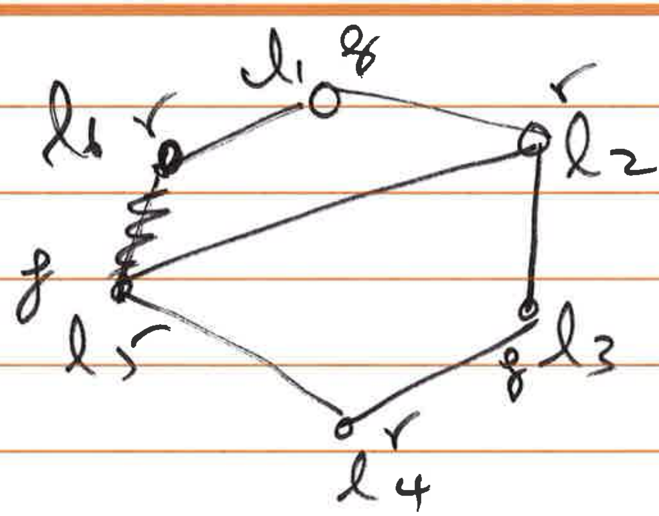

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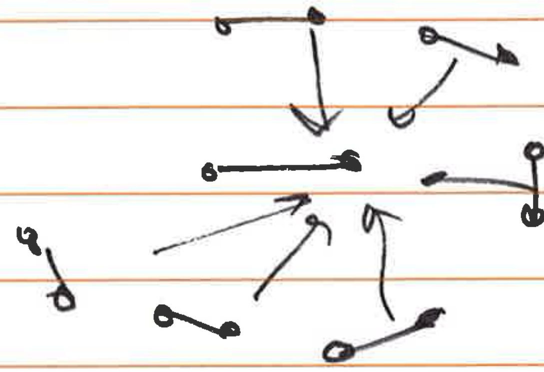

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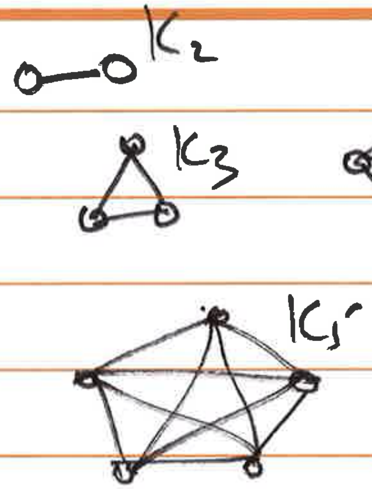

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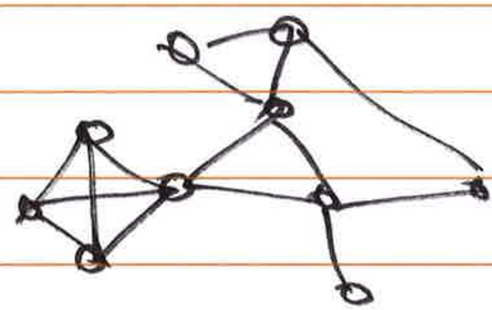

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