QUALIFYING CHARACTERISTICS OF LINK SHUTDOWN METHOD

WTC 2012 Conference
4-7 March 2012
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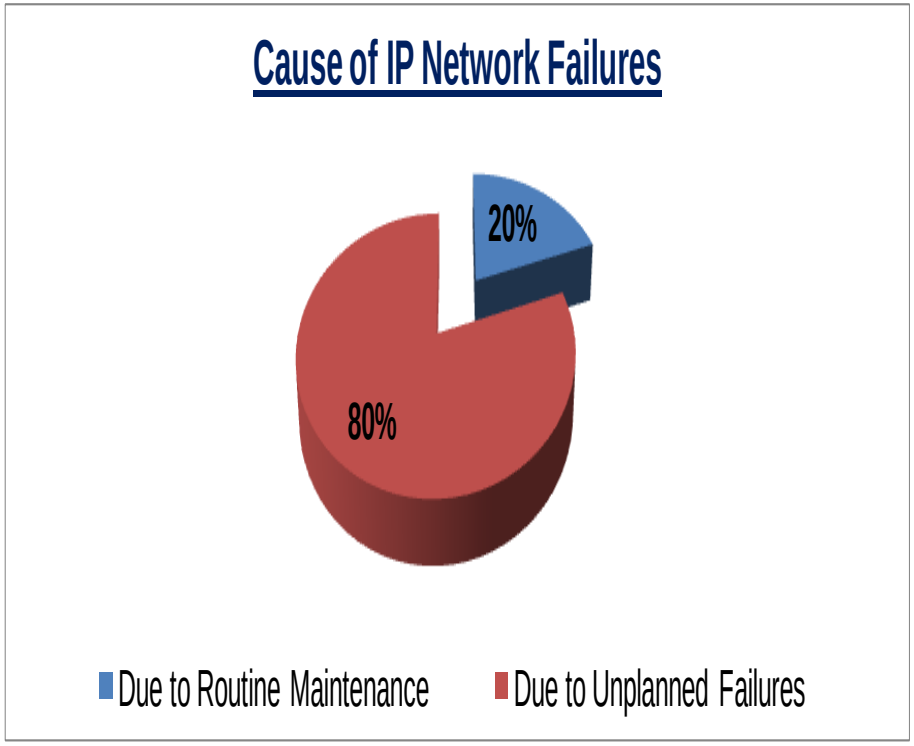
INTRODUCTION

Cause of IP Network Failures

- Shutting down a link due to routine maintenance is considered as a planned network failure.

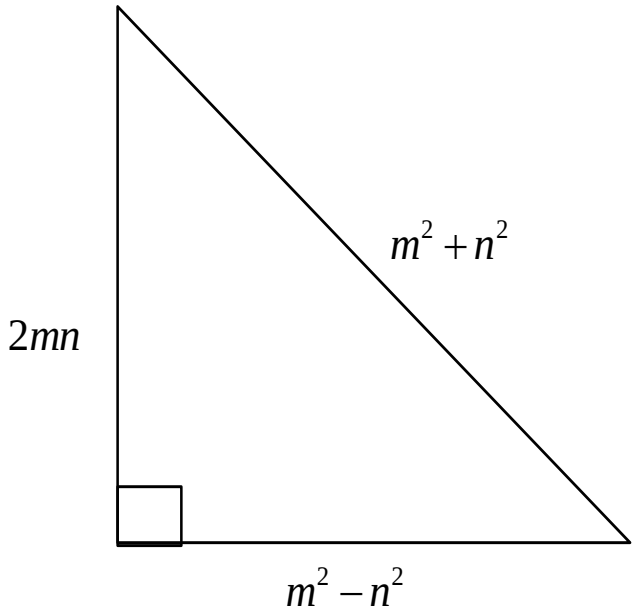


- Currently, ISPs use a graceful link shutdown method by first setting up the Interior Gateway Protocol (IGP) link metric to ***MAX_METRIC - 1*** and then shutdown the link.
- The link metric of a link can be increased to a larger metric by progressively increasing the metric of a link by 1, until the target metric is reached $\Rightarrow \; m_1 = m_0 + 1$
  - such that it cannot carry traffic anymore at which point the link can then be safely shutdown.
- We present that a ***Pythagorean Triple Metric Sequence*** can be used to shutdown a link during routine maintenance.

Using Pythagorean Triple Properties to Compute *MAX_METRIC – 1*

1. Using Euclid Formula:
   - ❖ Pythagorean triples from any two positive integers *m* and *n; m>n*.
   - ❖ In terms of sequence we have : *{a, b, c}*

$$\Rightarrow \{a = m^2 - n^2, b = 2mn, c = m^2 + n^2\}$$



- ❖ If *n = 1, the* triples are

$$\Rightarrow \{a = m^2 - 1, b = 2m, c = m^2 + 1\}$$

- ❖ Graceful Link Shutdown Method: ***MAX_METRIC – 1***
  - ➢ *Where m=256; n=1*

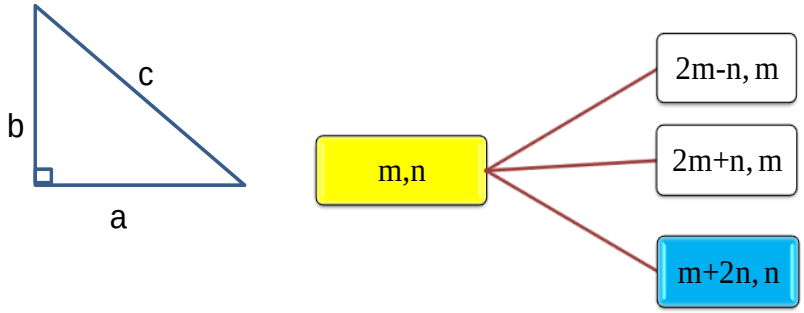
$$a = m^2 - n^2 = 256^2 - 1 = 65,535$$

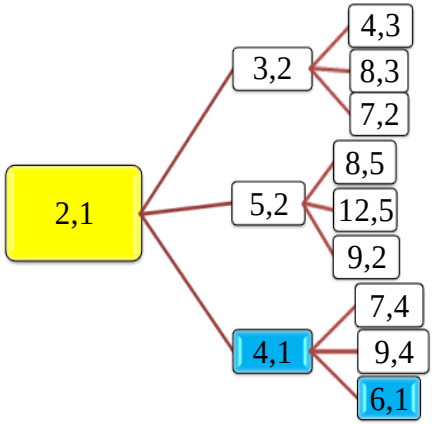
$$b = 2mn = 512$$

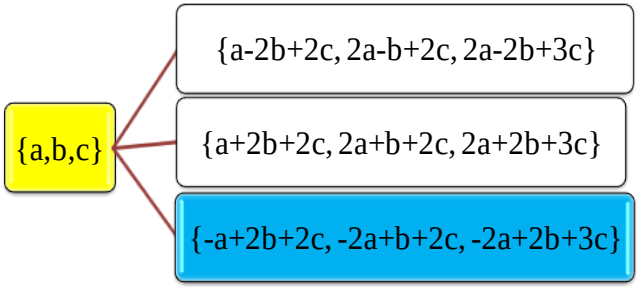
$$c = m^2 + n^2 = 256^2 + 1 = 65,537$$

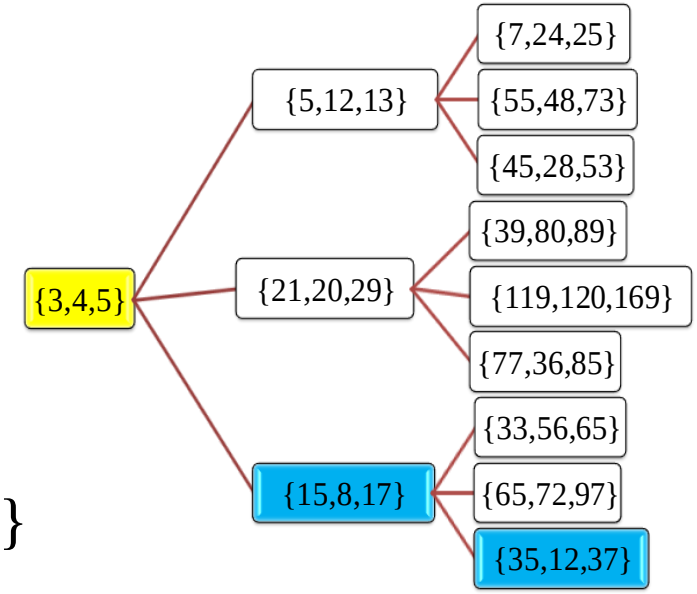
$$\Rightarrow a = MAX\_METRIC - 1 = 2^{16} - 1 = 256^2 - 1 = 65,535$$

Using Pythagorean Triple Properties and Genealogical Tree to Compute Pythagorean Triple Metric Sequence - Starting from {3,4,5}







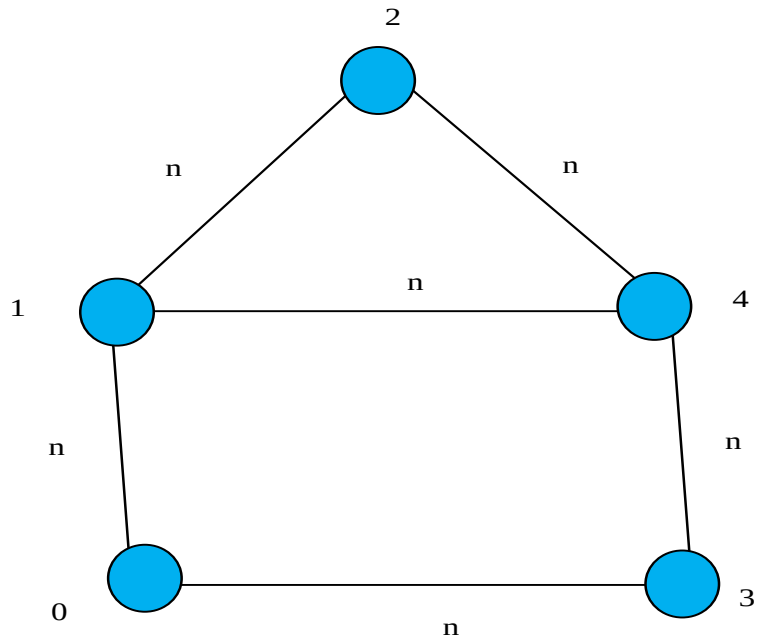


$$\Rightarrow \{a = m^2 - n^2, b = 2mn, c = m^2 + n^2\}$$

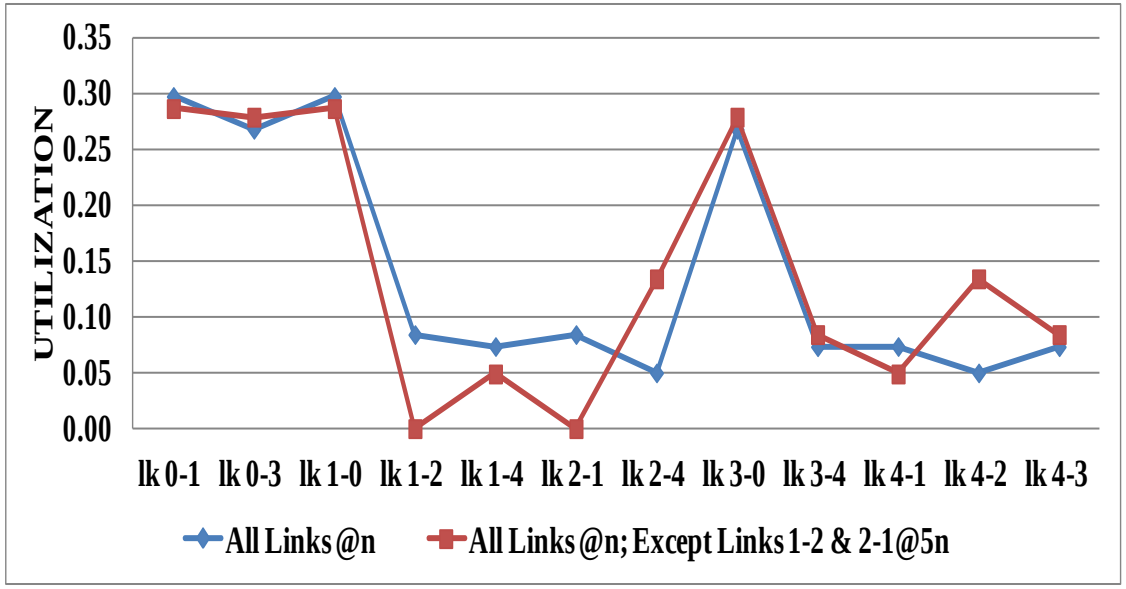
Using the Pythagorean Triple Metric Sequence Method we Compute Target Metrics for Link Shutdown

- If *{a, b, c}* is a Pythagorean triple, so is *{ka, kb, kc}* for any positive integer *k*, and that the smallest Pythagorean Triple is *{3, 4, 5}* when *k=1*.
- The *{3, 4, 5}* triple and its multiples *{3n, 4n, 5n}* are the only Pythagorean triple that are in *arithmetic progression* and *consecutively incrementing*.
- *We use the* Pythagorean Triple Sequence *{3n, 4n, 5n} to determine a* sequence of link metrics as target metrics to use to shut down a link.

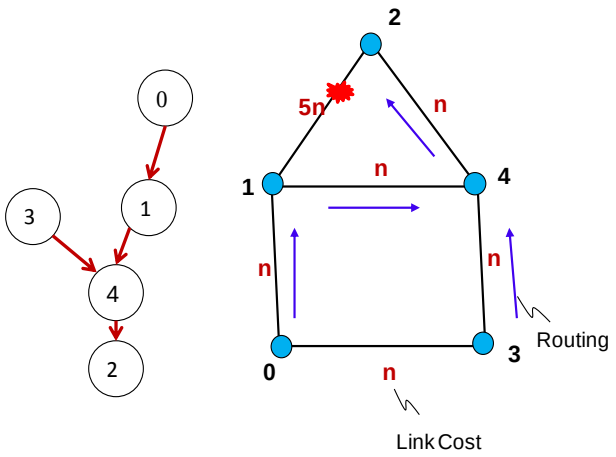
n	PRIMITIVE	TARGET METRIC
1	1 x 3, 4, 5	3, 4, 5
2	2 x 3, 4, 5	6, 8, 10
3	3 x 3, 4, 5	9, 12, 15
4	4 x 3, 4, 5	12, 16, 20
5	5 x 3, 4, 5	15, 20, 25
…	…	…
n	n x 3, 4, 5	3n, 4n, 5n



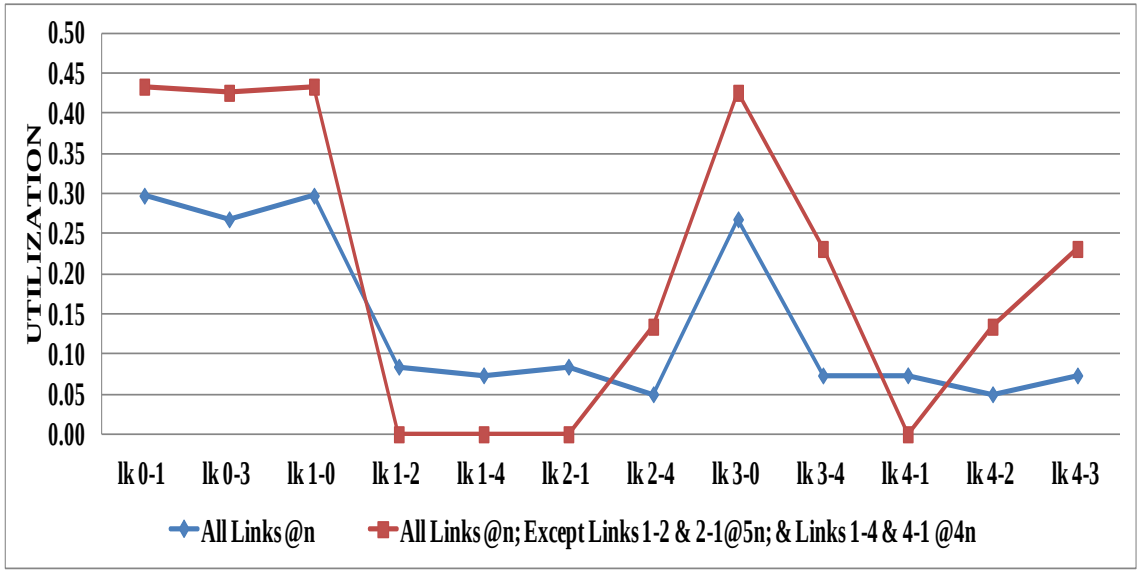
Result of using Pythagorean Triple to Shut Down a Link



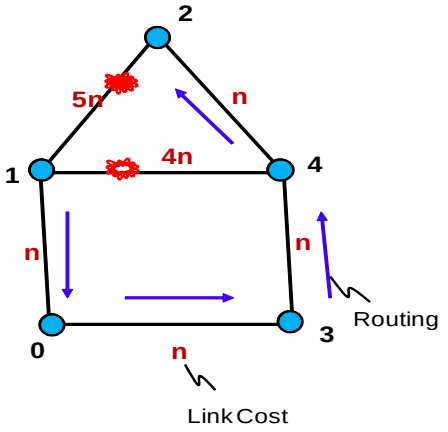
❑When we shutdown links 1-2/2-1 traffic destined for node 2 routing is:



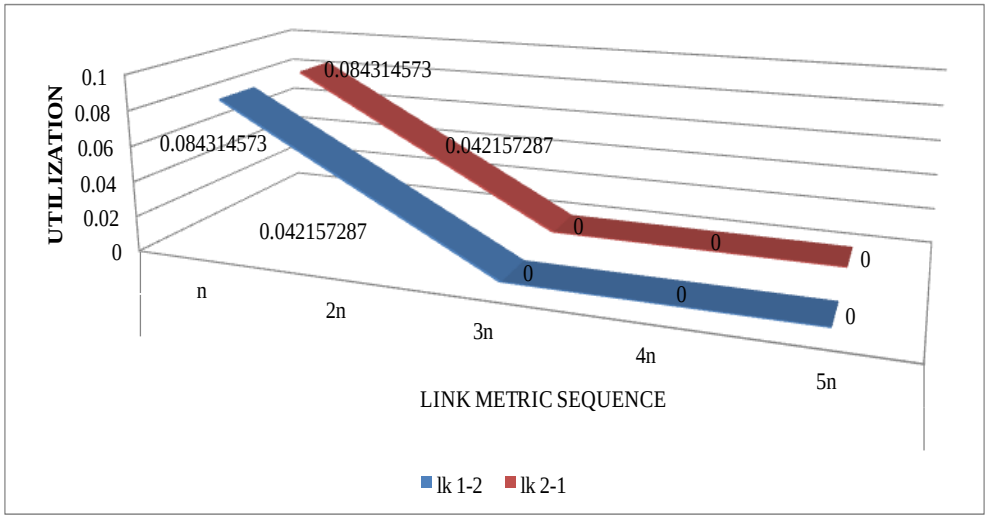
Result of using Pythagorean Triple to Shut Down Two Links



❑We are also able to shutdown two links (e.g. 1-2/2-1 and 1-4/4-1) using our Method.

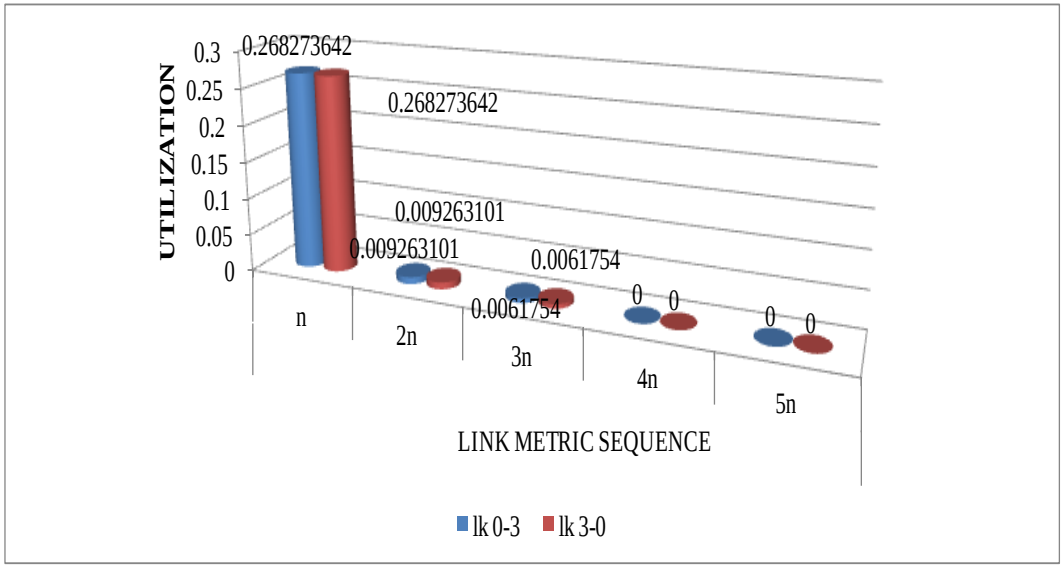


Links that can be shut down when link cost reaches the link metric of {3n, 4n, 5n}



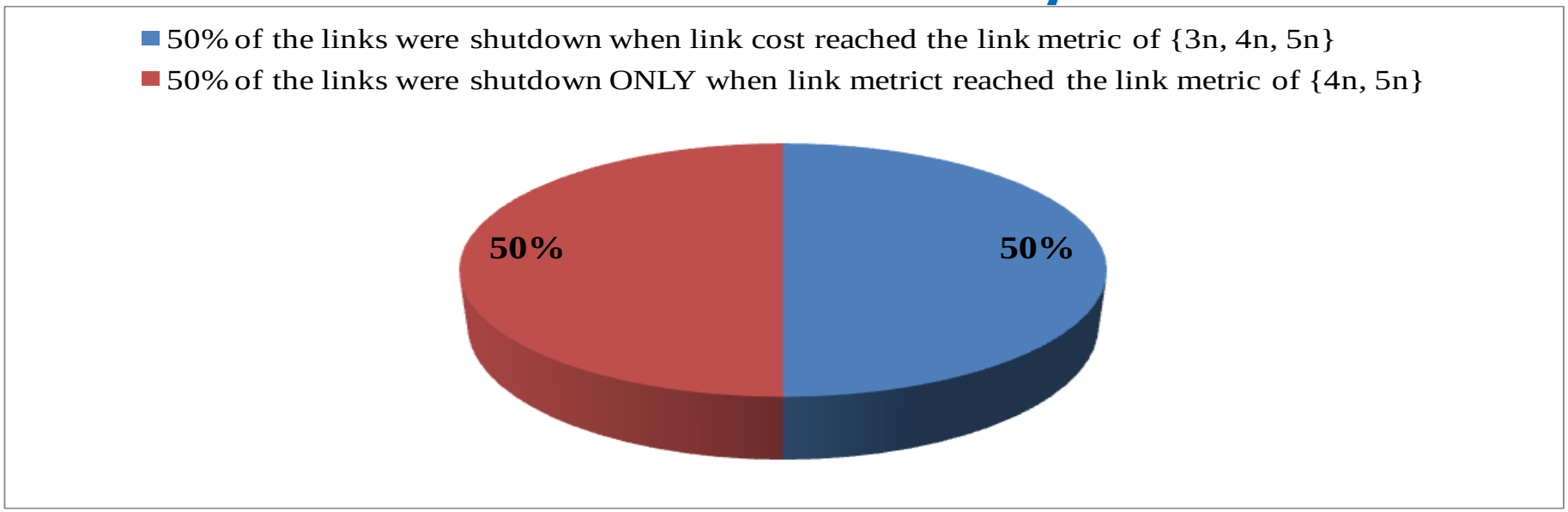
- During our experiments each link was configured to *{n, 2n, 3n, 4n, 5n}* link metric;
- Some links it is only when the link metric reached *{3n, 4n, 5n}* that the link utilization was zero.

Links that can be shut down ONLY when link cost reaches the link metric of {4n, 5n}



- Whereas other links it is only when the link metric reached *{4n, 5n}* that the link utilization became zero.

Our Simulation Results in Summary & Conclusion



- We have presented a link shutdown method using the ***Pythagorean Triple Metric Sequence*** *that can be used to configure and shutdown* a link for routine maintenance.
- Thus when a link is scheduled for routine maintenance the link can be configured to <u>one</u> of the metric in the sequence *{3n, 4n, 5n}* as the target metric before shutdown.
- Future work, we plan to investigate the use of other *Pythagorean Triple Sequences* other than the {3*n, 4n, 5n}.*