
cisco Live!
ALL IN

The bridge to possible

Koomey's Electric Consumption Law and ASR9K Family

Leon Yang, CCIE #27802
Consulting Engineer, CX

BRKGEN-2004

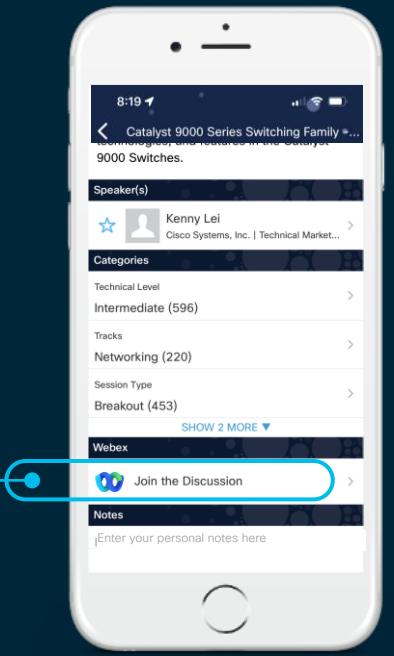
Cisco Webex App

Questions?

Use Cisco Webex App to chat
with the speaker after the session

How

1. Find this session in the Cisco Live Mobile App
2. Click “Join the Discussion”
3. Install the Webex App or go directly to the Webex space
4. Enter messages/questions in the Webex space



https://ciscolive.ciscoevents.com/ciscolivebot/#BRKGEN-2004

Webex spaces will be moderated by the speaker until June 17, 2022.

Agenda

- Introduction
- Koomey's Law
- Application to Telecom
- ASR9K Family
- Bandwidth and Power Consumption
- Conclusion

Agenda

- Introduction
- Koomey's Law
- Application to Network Industry
- ASR9K Family
- Bandwidth and Power Consumption
- Conclusion

Introduction

Background

- Internet traffic reached 292.8 Exabytes per month in 2022
- More ordinary devices are on-line today
- SP’s need more bandwidth to provide more services
- Footprint, power consumption, potential to grow

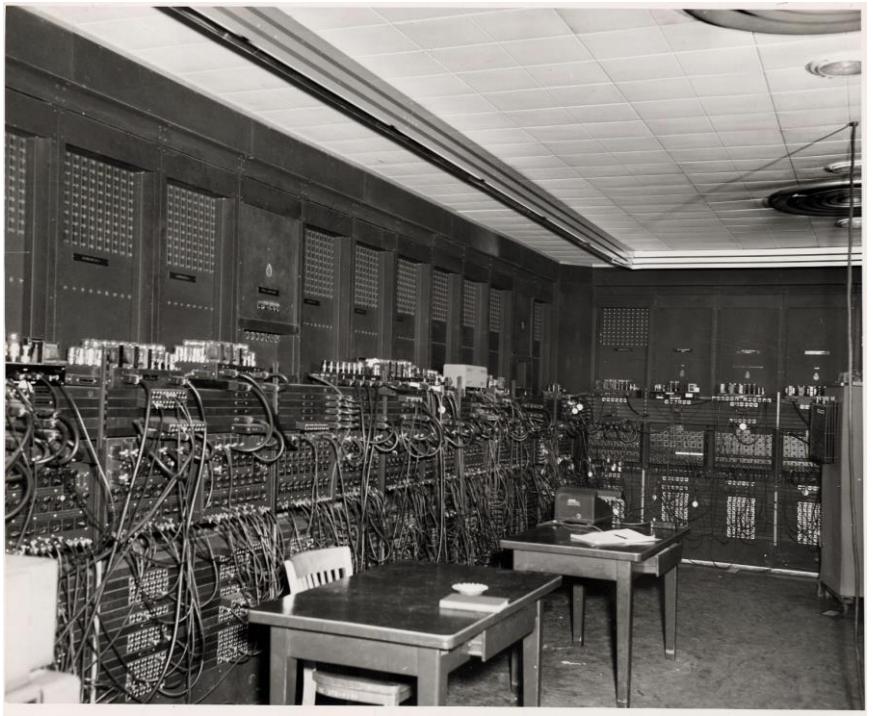
Counting

Computing

Machines

ENIAC - Turing-Complete Computer

- Memory: 20 words
- Fast: 5000 + -; 50 * /s
- Consumed ~200 kW
- 437 comp per kWh
- Made public on Valentine Day 1946



Koomey’s Law

Computations per kilowatt-hour

- Number double every 1.57 years
- Power reduce half in 18 months

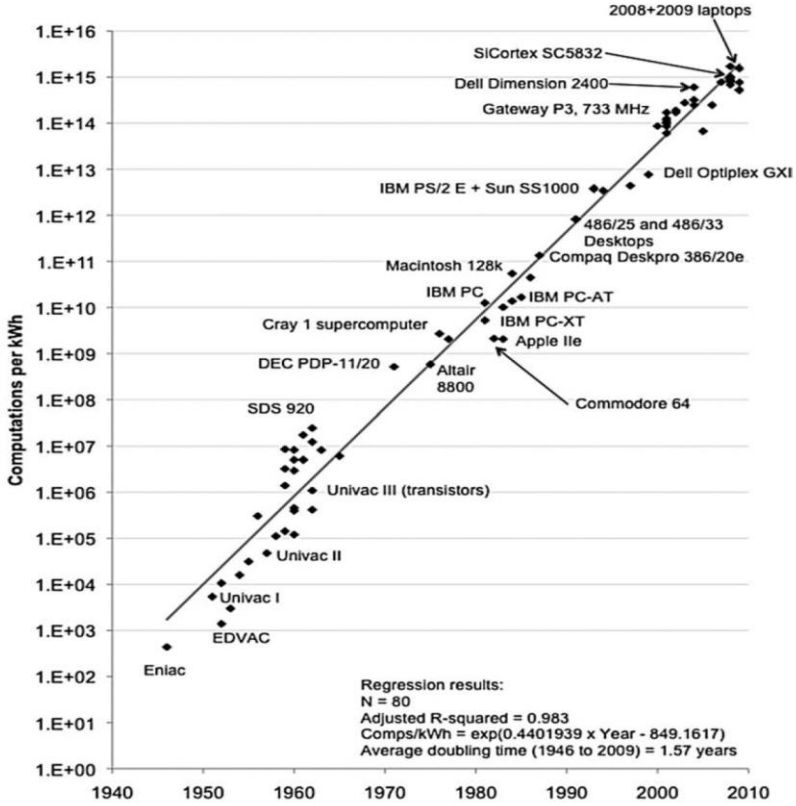


Figure 3. Computations per kilowatt-hour over time. These data include a range of computers, from PCs to mainframe computers and measure computing efficiency at peak performance. Efficiency doubled every 1.57 years from 1946 to 2009.

“Computations per kilowatt-hour efficiency doubled every 1.57 years from 1946 to 2009.”

Jonathan Koomey et al

IEEE Annals of the History of Computing. vol. 33, no. 3. July-Sept, 2011

Koomey's Law

- Computations per kWh doubled every 1.57 years – 2010
- Every 18 months power dissipation reduced by half
- Not a Law of physics or nature, just an observation
- This cannot go forever
- Trend slowed to every 2.6 years – Koomey 2016

What Does It Mean?

- The number of computations one kWh produced
- Full-load computational capacity
- Focused on hardware, but not 100%
- Not count the electricity used to cool the computer
- Came after Moore's Law

Application to Network Industry

Koomey's Law in the Network Context

- Peak output energy efficiency
- 3% of all electricity used in the world goes to data centers
- Computing faster means moving bits faster, not always true
- The role of a Router matters
- Fans use significant part of power

Power Usage in the Network Context

- How is electricity used in a network device, router
  - Packet path: optics, packet size, rules, etc
  - Electricity path: 8% for PEMs, 5-10% for voltage conversion
  - LC, FC and other modules
- Ambient temperature

Other Things to Consider

Implementation	Running time
Python 3	~ 9 hour
Python 2	~ 7 hour
Java	~ 40 min
C	9 min

4096 x 4096 matrix-multiplication:

```
for i in xrange(4096):
    for j in xrange(4096):
        for k in xrange(4096):
            C[i][j] += A[i][k] * B[k][j]
```

Source: Leiserson et al., Science 368, 1079 (2020)

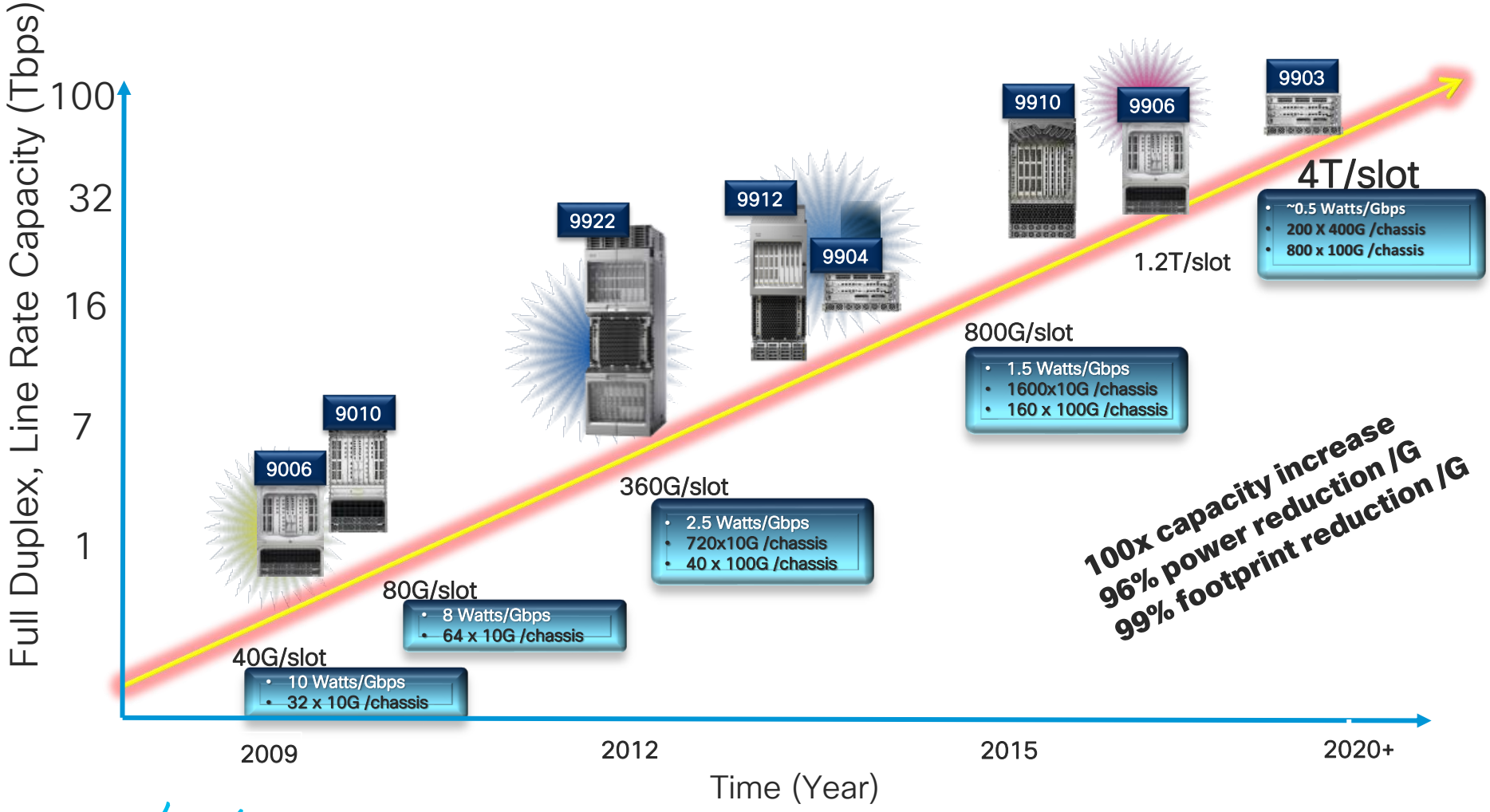
Further Narrow Down

- Peak output energy efficiency only for reference
- Relative numbers, real environment
- Density and speed
- Fan efficiency
- **Focus on Cisco ASR9K in production environment**

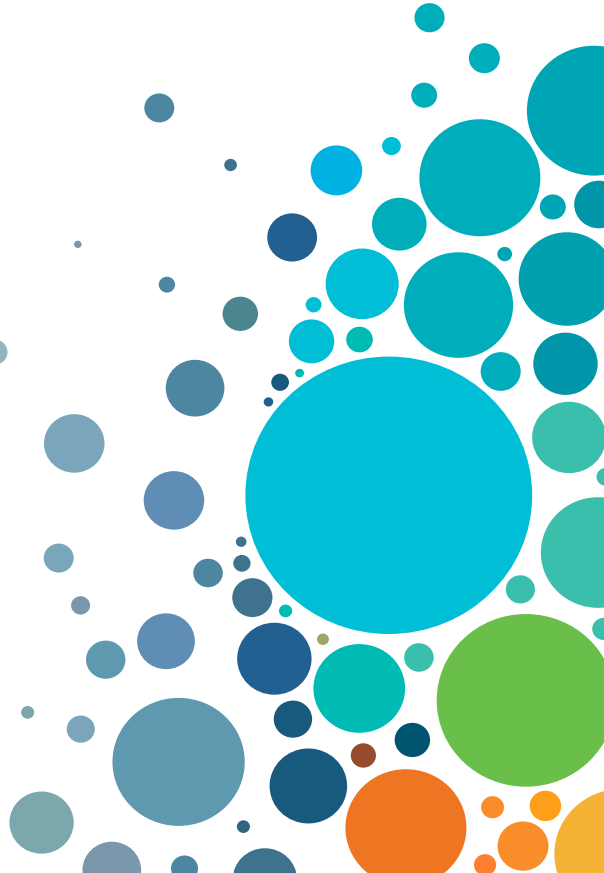
ASR9K Family

Why ASR9K

- More than 100,000 chassis deployed (up to 2020)
- One of the most trusted service provider platforms
- Feature rich, Core, Edge, Aggregation, Peering, DCI and BNG
- Integrated APIs, ZTP, YANG, Open Config models
- 400GE Ready



Bandwidth and Power Consumption Studies



Methodology

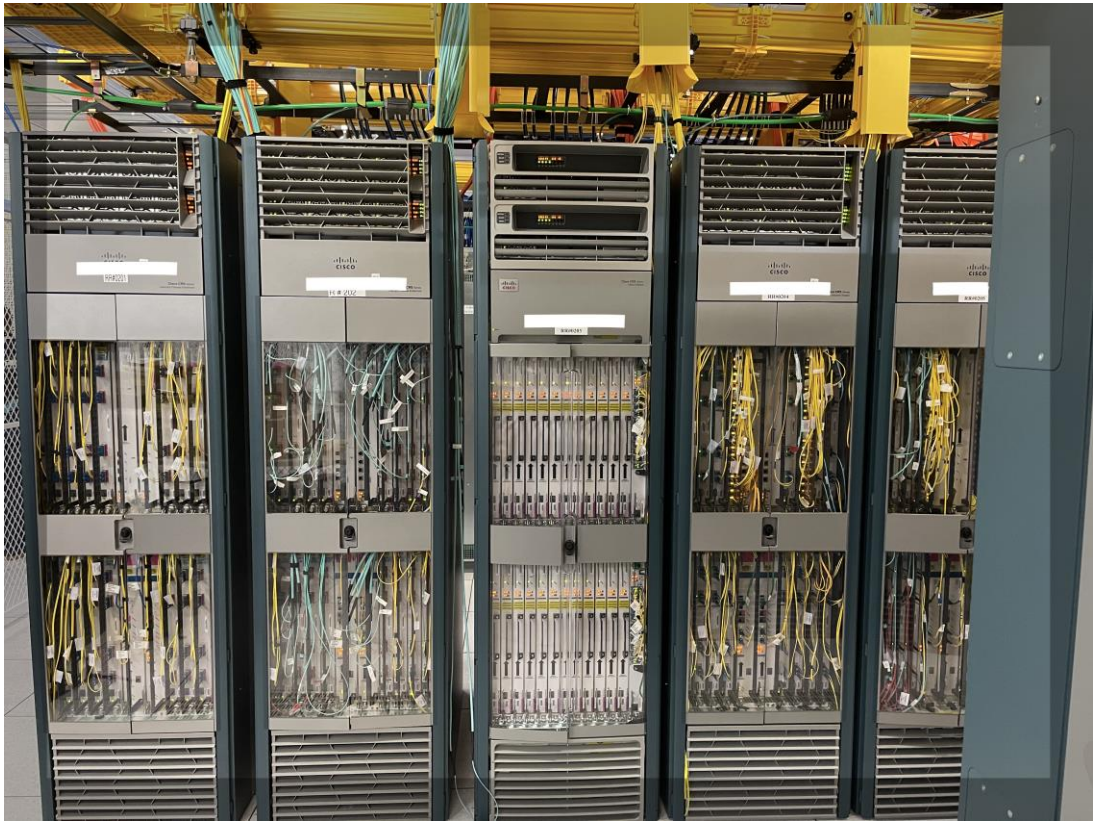
- Study the “SAME” router in real life
- Data are gathered before and after migration
- No configuration change
- No traffic pattern change
- Due to router roles, results are not “perfect”

Backbone Router from MC-CRS to ASR9922

cisco Live!

MC-CRS

- CRS 8+1
- Backbone router
- 434 100Gig, 93 10G Ports
- Total output power 83KW
- Inside a Colo



MC-CRS – Total Power (W): 83,187.029

Rack		A-Side	B-Side
0	Total Power (W):	5385.875	5164.2
1	Total Power (W):	5150.518	5287.352
2	Total Power (W):	5199.778	5394.085
3	Total Power (W):	2586.204	2870.825
4	Total Power (W):	4272.088	4053.908
5	Total Power (W):	5028.675	5679.696
6	Total Power (W):	5187.032	5398.174
7	Total Power (W):	5457.998	5370.023
FC0	Total Power (W):	2827.038	2873.56

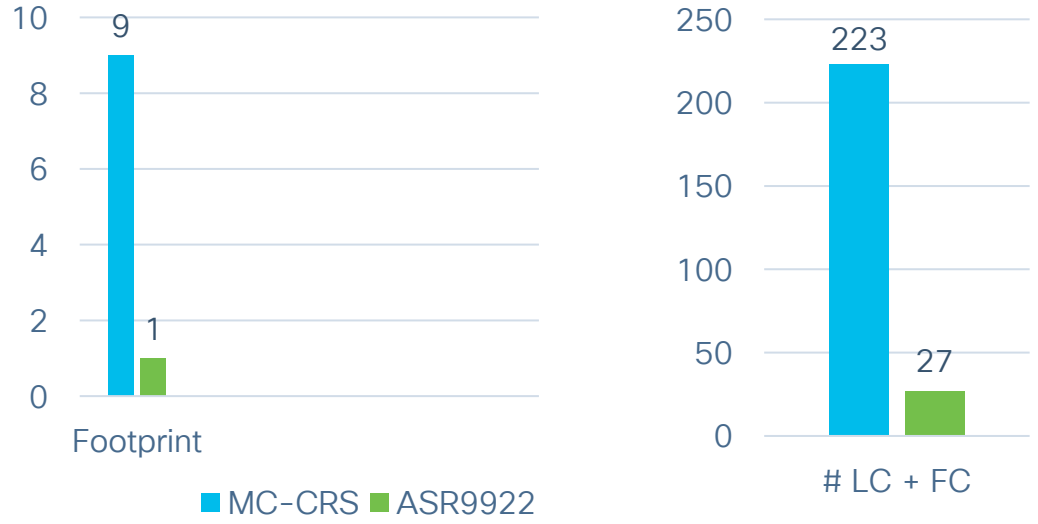
BBR: ASR9922 5th and 3rd Gen

Power usage

- Allocated 28KW
- Actual 20,094W

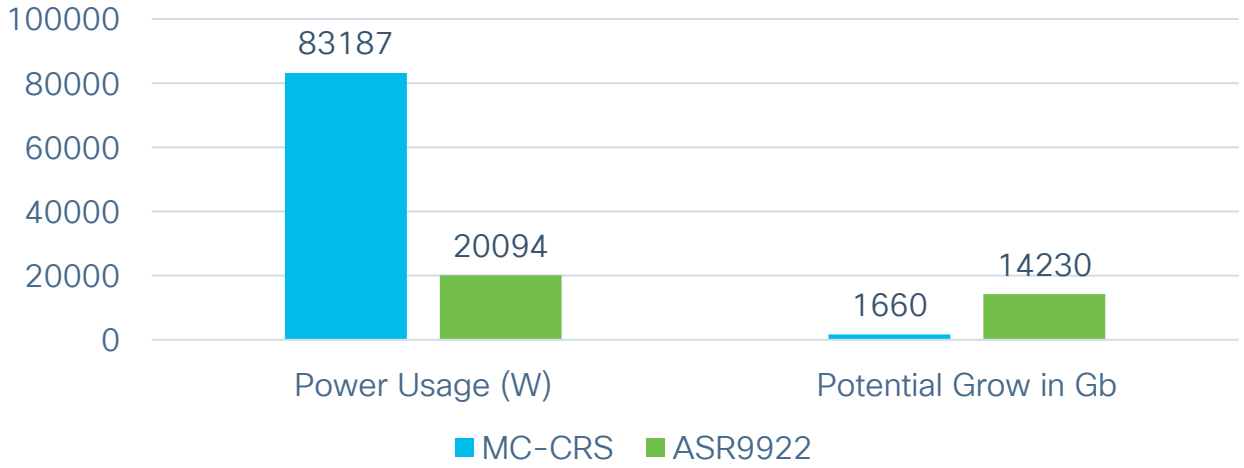
ASR9922 eXR						
Location	Card Type	Allocated W	Used W	Status	100G	10G
0/0	A99-32X100GE-X-SE	1050	799	ON	32	
0/1	A99-32X100GE-X-SE	1050	803	ON	32	
0/2	A99-32X100GE-X-SE	1050	808	ON	32	
0/3	A99-32X100GE-X-SE	1050	805	ON	32	
0/4	A99-32X100GE-X-SE	1050	686	ON	4	
0/5	A99-32X100GE-X-SE	1050	650	ON	0	
0/6	A99-32X100GE-X-SE	1050	654	ON	0	
0/7	A99-32X100GE-X-SE	1050	669	ON	2	
0/8	A99-32X100GE-X-SE	1050	782	ON	32	
0/9	A99-32X100GE-X-SE	1050	772	ON	32	
0/10	A99-32X100GE-X-SE	1050	813	ON	32	
0/11	A99-32X100GE-X-SE	1050	797	ON	32	
0/12	A99-32X100GE-X-SE	1050	792	ON	32	
0/13	A99-32X100GE-X-SE	1050	800	ON	32	
0/14	A99-32X100GE-X-SE	1050	802	ON	32	
0/15	A99-32X100GE-X-SE	1050	756	ON	23	
0/16	A99-32X100GE-X-SE	1050	749	ON	22	
0/17	A99-32X100GE-X-SE	1050	788	ON	31	
0/18	A99-48X10GE-1G-SE	810	395	ON		47
0/19	A99-48X10GE-1G-SE	810	410	ON		46
0/RP0	A99-RP3-TR	275	226	ON		
0/RP1	A99-RP3-TR	275	180	ON		

MC-CRS Migrate to ASR9922



Physical comparison

MC-CRS Migrate to ASR9922 Power Usage Decrease 76% !



Depending on the traffic amount at that moment the values may vary.

Watt per Gigabit – 76% Decrease!

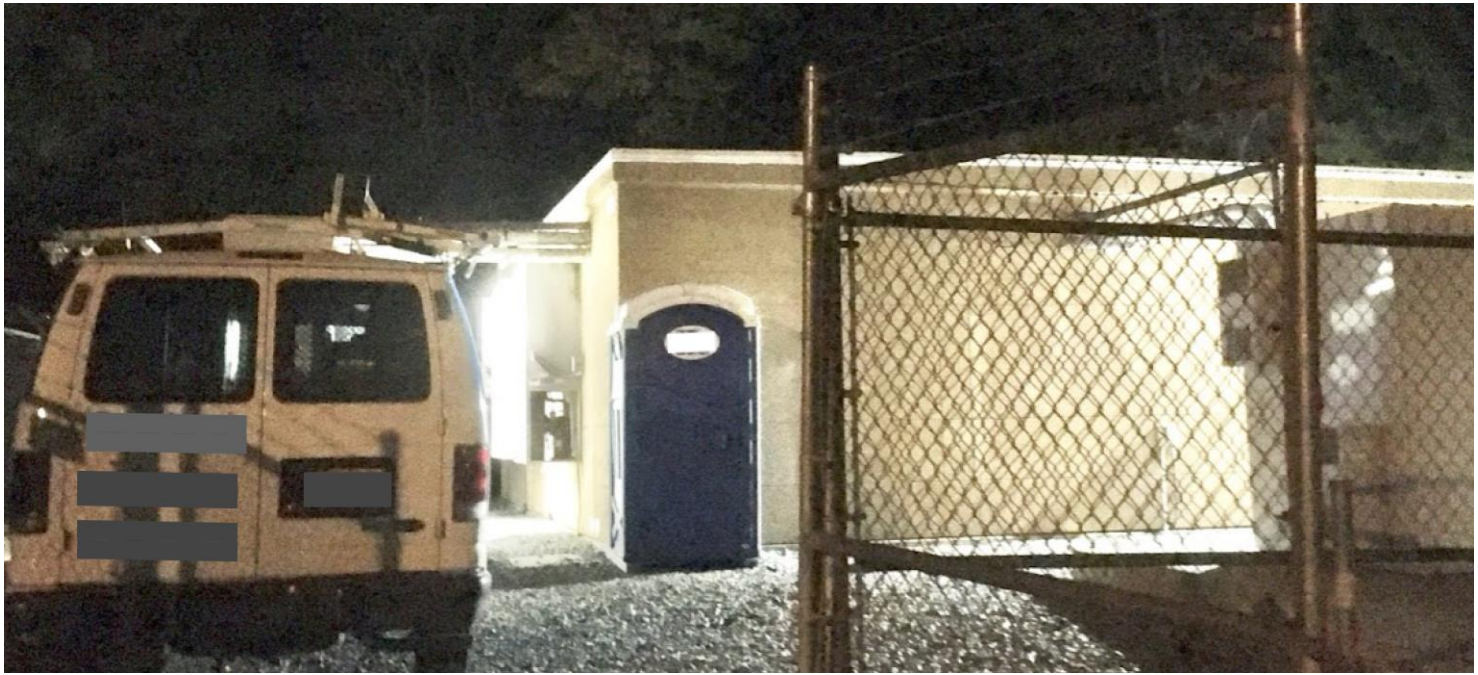
MC-CRS	eXR ASR9922
1.88	0.45

Average industry electricity rate is 6.9 cents per kWh in NC. The new router saves $3134.46 each month.

Core Router from cXR to eXR

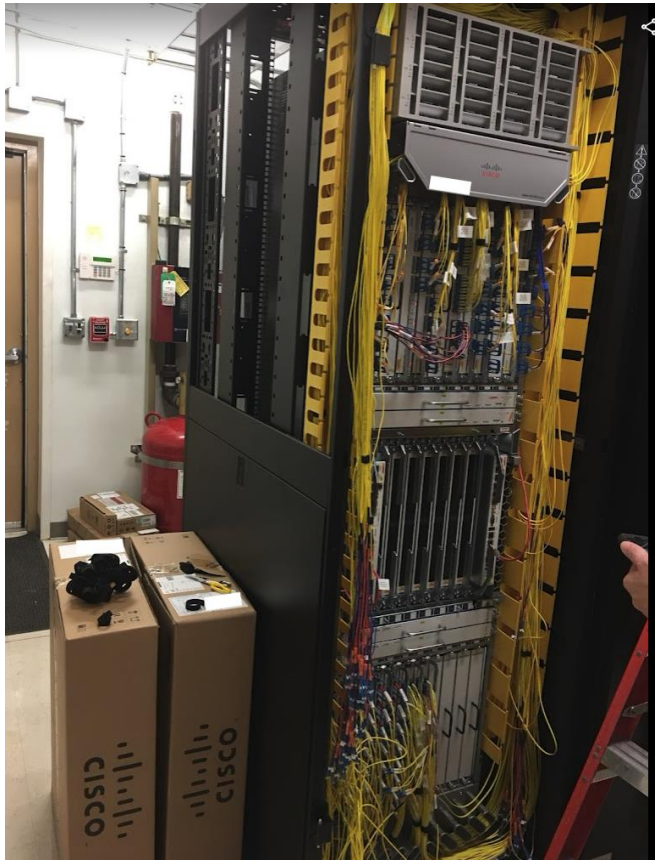
cisco Live!

Core Router at hub-site



ASR9922 cXR

- RP2 x 2
- FAN-V2 x 4
- SFC2 x 7
- 364 10Gig Ports
- 40 100G Ports



Before Migration

- 2nd and 3rd Gen LC's
- 15 LC's, 7 FC's
- 5 empty slots

0/0/CPU0	A99-8X100GE-TR		6
0/1/CPU0			
0/2/CPU0	A99-8X100GE-TR		8
0/3/CPU0	A99-8X100GE-TR		8
0/4/CPU0			
0/5/CPU0			
0/6/CPU0			
0/7/CPU0	A99-8X100GE-TR		7
0/8/CPU0	A99-8X100GE-TR		3
0/9/CPU0	A99-8X100GE-TR		8
0/10/CPU0	A99-8X100GE-TR	76	
0/11/CPU0			
0/12/CPU0	A9K-36x10GE-TR	36	
0/13/CPU0	A9K-36x10GE-TR	36	
0/14/CPU0	A9K-36x10GE-TR	36	
0/15/CPU0	A9K-36x10GE-TR	36	
0/16/CPU0	A9K-36x10GE-TR	36	
0/17/CPU0	A9K-36x10GE-TR	36	
0/18/CPU0	A9K-36x10GE-TR	36	
0/19/CPU0	A9K-36x10GE-TR	36	
	Total	364	40

Before Migration Power Usage

Modules	Power Used Watts
2 RP's	354.2
7 FC's	604
15 LC's	11093.3
Total (without FAN's)	12051.5
4 FAN Trays	6600 **
Total	**18651.5**

** *worst scenario*

After Migration, eXR

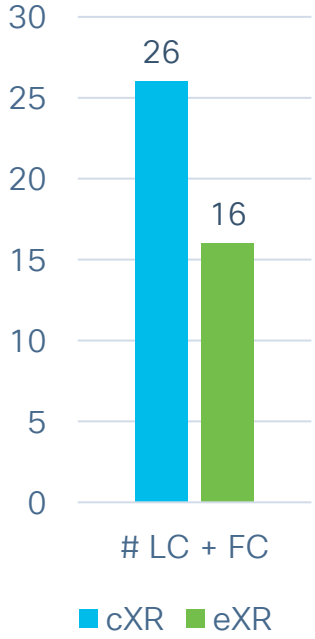
- V3 RP's, FC's, FAN's
- 3rd and 4th Gen LC's
- 9 LC's, 7 FC's
- 11 slots are available

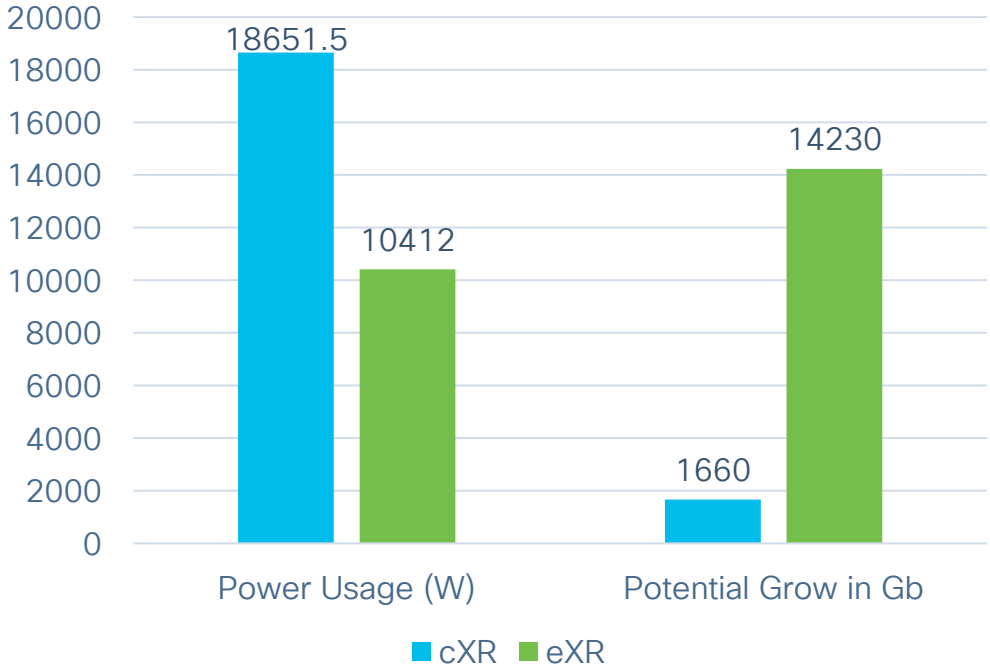
0/0	A99-32X100GE-TR		22
0/7	A99-8X100GE-TR		7
0/9	A99-32X100GE-TR		11
0/10	A99-8X100GE-TR	76	
0/11	A99-8X100GE-TR	78	
0/12	A99-8X100GE-TR	80	
0/13	A99-8X100GE-TR	80	
0/14	A99-8X100GE-TR	50	
0/18	A99-48X10GE-1G-TR		
	Total	364	40

After Migration Power Usage

Modules	Power Used Watts
2 RP's	388
7 FC's	758
9LC's	6543
Total (without FAN's)	7689
4 FAN Trays	2723
Total	**10412**

ASR9922 cXR Migrate to eXR Lightspeed Power Usage Decrease 44% !





Watt per Gigabit – Reduce 44%

cXR ASR9922	eXR ASR9922
2.44	1.36

Average industry electricity rate is 6.9 cents per kWh in NC. The new router saves $409.34 each month.

ASR 9000 LC Evolution

Gen	Card Type	Watts	W/G
5	A99-32X100GE-X-SE	1050	0.33
4	A99-32X100GE-TR	1350	0.42
3	A99-8X100GE-TR	1150	1.44
3	A99-48X10GE-1G-TR	810	1.69
3	A9K-MOD400-TR	1100	2.75
2	A9K-MOD80-TR	400	5
1	A9K-40GE-TR	275	6.88

ASR9K has made lots of progress in power efficiency

Koomey's Law is still true in our industry

Conclusion

Cisco 8000 Is Next

- Cisco 8000 is even better
  - One of the new features: Dynamic power management
  - W/G reaches 0.11, only one third of Gen-5
- Will provide update about footprint, power consumption and potential to growth data

Technical Session Surveys

- Attendees who fill out a minimum of four session surveys and the overall event survey will get Cisco Live branded socks!
- Attendees will also earn 100 points in the Cisco Live Game for every survey completed.
- These points help you get on the leaderboard and increase your chances of winning daily and grand prizes.

Cisco Learning and Certifications

From technology training and team development to Cisco certifications and learning plans, let us help you empower your business and career. www.cisco.com/go/certs

Pay for Learning with Cisco Learning Credits

(CLCs) are prepaid training vouchers redeemed directly with Cisco.

Learn

Cisco U.
IT learning hub that guides teams and learners toward their goals

Cisco Digital Learning
Subscription-based product, technology, and certification training

Cisco Modeling Labs
Network simulation platform for design, testing, and troubleshooting

Cisco Learning Network
Resource community portal for certifications and learning

Train

Cisco Training Bootcamps
Intensive team & individual automation and technology training programs

Cisco Learning Partner Program
Authorized training partners supporting Cisco technology and career certifications

Cisco Instructor-led and Virtual Instructor-led training
Accelerated curriculum of product, technology, and certification courses

Certify

Cisco Certifications and Specialist Certifications
Award-winning certification program empowers students and IT Professionals to advance their technical careers

Cisco Guided Study Groups
180-day certification prep program with learning and support

Cisco Continuing Education Program
Recertification training options for Cisco certified individuals

Here at the event? Visit us at **The Learning and Certifications lounge at the World of Solutions**

Continue your education

- Visit the Cisco Showcase for related demos
- Book your one-on-one Meet the Engineer meeting
- Attend the interactive education with DevNet, Capture the Flag, and Walk-in Labs
- Visit the On-Demand Library for more sessions at www.CiscoLive.com/on-demand

cisco Live!

Thank you


cisco Live!
ALL IN