Intrusive and Unobtrusive Assessment of Entrepreneurial and Technical Skills through Simulation and Gaming

John T. Behrens, Ph.D. jbehrens@cisco.com

Dennis Frezzo, Ph.D. dfrezzo@cisco.com

Kristen DiCerbo, Ph.D. kdicerbo@cisco.com

Cisco | Networking Academy®
Mind Wide Open™

It takes a village to think make assessment

Youn Young Choi, UMD

Dan Robinson, UT

AAron Crawford, ASU

Roy Levy, ASU

Kristen DiCerbo

Bob Mislevy, ETS

Dennis Frezzo, Cisco

Mark Chen, Cisco

Philip Piety

Daisy Rutstein, UMD

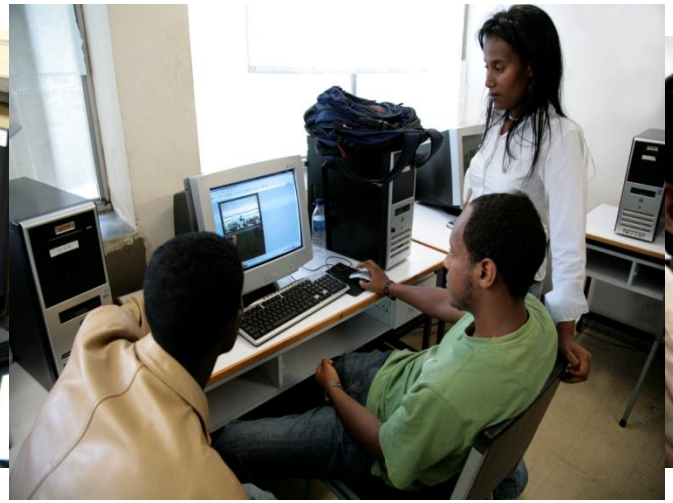
Junhui Liu, UMD

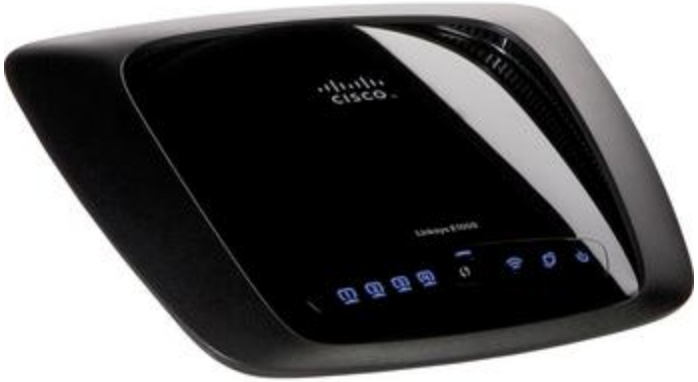
Patti West, Cisco

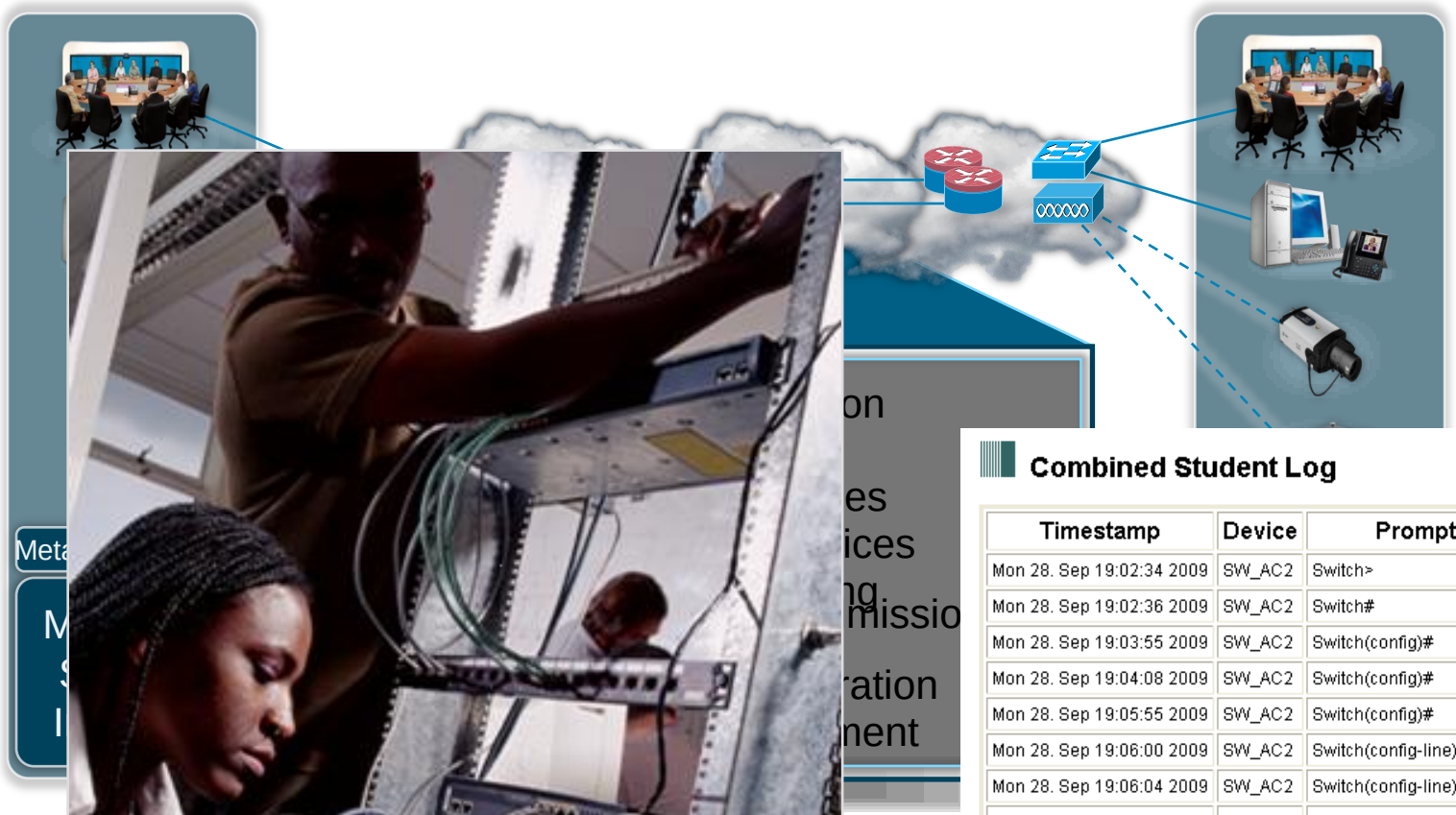
Telethia Willis, Cisco

A play in 3 acts

- Who we are and where we come from
- Some intrusive assessment
- Some unobtrusive assessment (or is it something else?)



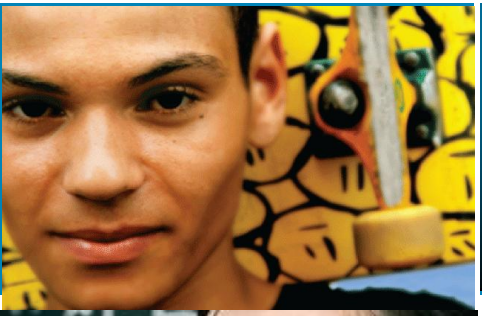




Combined Student Log

Timestamp	Device	Prompt	Command
Mon 28. Sep 19:02:34 2009	SW_AC2	Switch>	enable
Mon 28. Sep 19:02:36 2009	SW_AC2	Switch#	conf t
Mon 28. Sep 19:03:55 2009	SW_AC2	Switch(config)#	enable secret class
Mon 28. Sep 19:04:08 2009	SW_AC2	Switch(config)#	no ip domain-lookup
Mon 28. Sep 19:05:55 2009	SW_AC2	Switch(config)#	line console 0
Mon 28. Sep 19:06:00 2009	SW_AC2	Switch(config-line)#	password cisco
Mon 28. Sep 19:06:04 2009	SW_AC2	Switch(config-line)#	login
Mon 28. Sep 19:06:10 2009	SW_AC2	Switch(config-line)#	line vty 0 15
Mon 28. Sep 19:06:16 2009	SW_AC2	Switch(config-line)#	password cisco
Mon 28. Sep 19:06:29 2009	SW_AC2	Switch(config-line)#	login
Mon 28. Sep 19:09:37 2009	SW_AC2	Switch(config-line)#	banner mode#
Mon 28. Sep 19:09:46 2009	SW_AC2	Switch(config-line)#	banner motd#
Mon 28. Sep 19:10:01 2009	SW_AC2	Switch(config-line)#	end
Mon 28. Sep 19:10:06 2009	SW_AC2	Switch#	conf t
Mon 28. Sep 19:10:15 2009	SW_AC2	Switch(config)#	banner motd #
Mon 28. Sep 19:14:23 2009	SW_AC2	Switch(config)#	hostname SW_AC2
Mon 28. Sep 19:15:02 2009	SW_AC2	SW_AC2(config)#	interface vlan 43
Mon 28. Sep 19:16:15 2009	SW_AC2	SW_AC2(config-if)#	ip address 172.16.43.12 255

Corporate Social Responsibility and Cisco Networking Academy



Large and Global

165 Countries
1 Million Students engaged this year
3.75 Million Students since inception

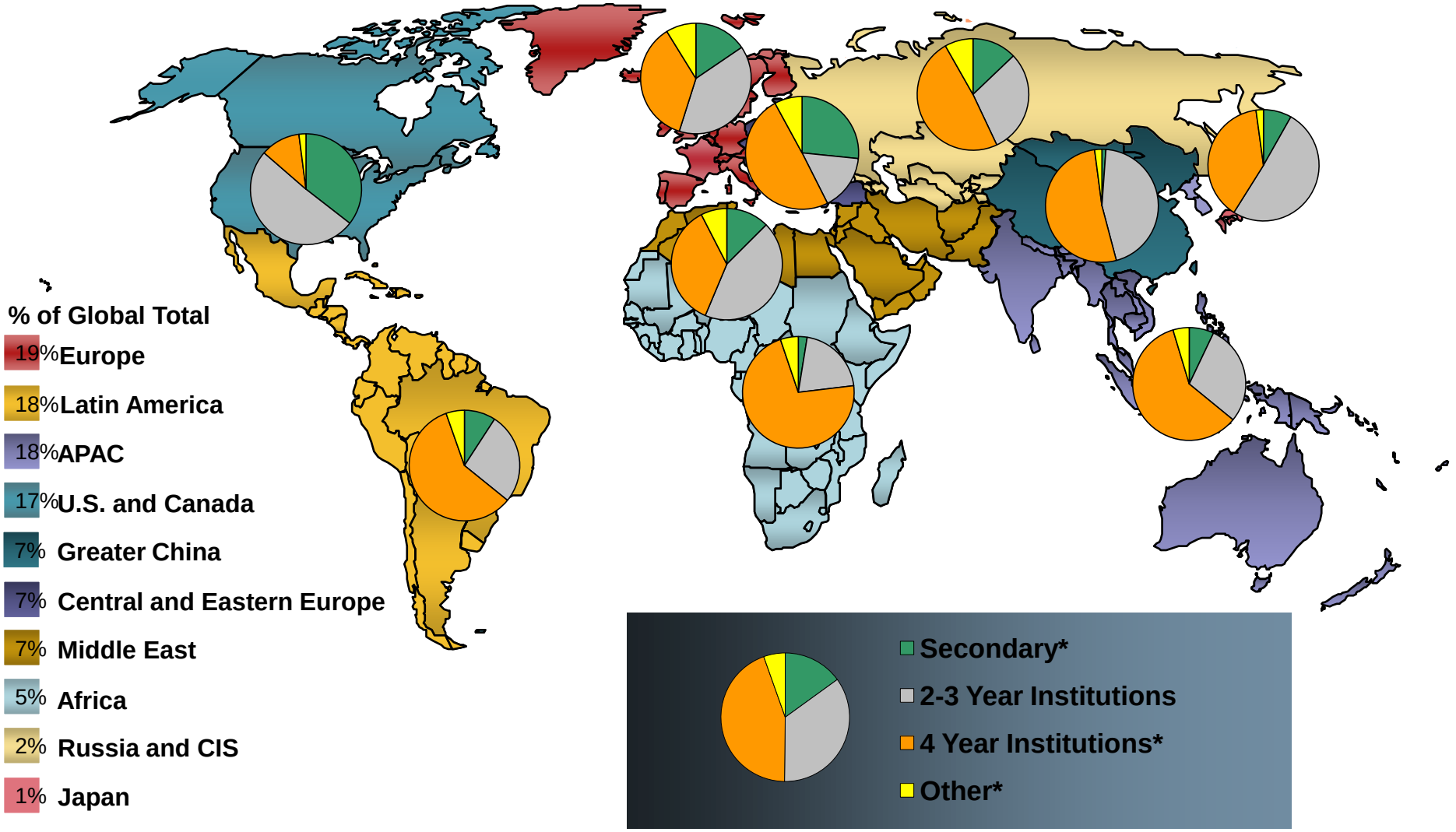
Diverse Students and Communities

Students: Diverse Age, Gender, and Circumstances
Communities: Mature and Developing

Diverse Educational Institutions

Universities, Community Colleges, Vocational Schools, Secondary Schools, Non-profit Organizations, Second Chance

Students by Education Level by Region (1,000,000 Students)



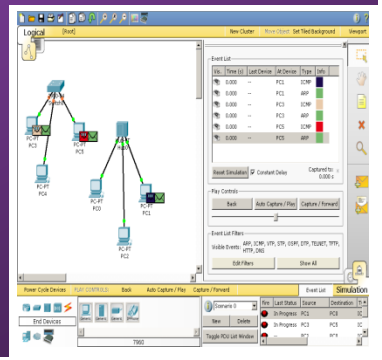
* See Notes Page for additional details on these definitions

Source: AME, jzinn_v1, Snapshot as of October 31, **2010**

A comprehensive educational partnership

Curricula

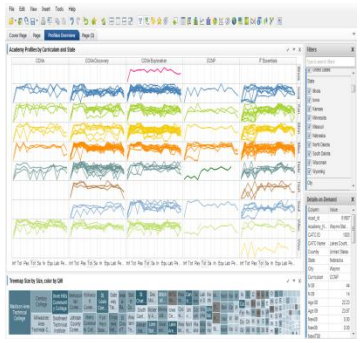
- 14 courses
- Entry-level tech skills
- Instructor-led
- Simulation and visualization software
- Hands-on experience
- Assessments



Relationships

- Students
- Academies
- Instructors
- Governments
- Partners

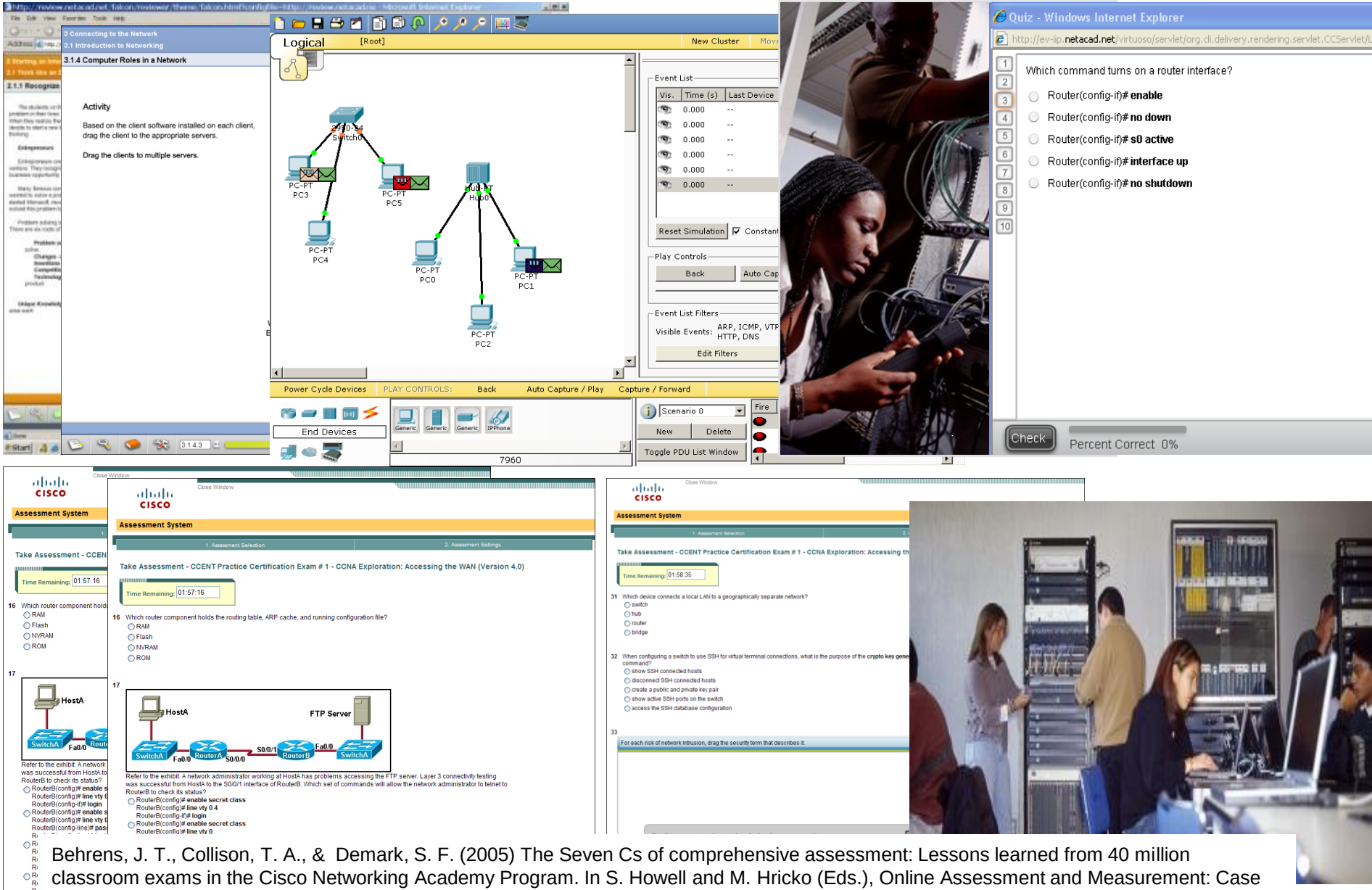
- Educational process and learning systems
- Larger server base than cisco.com
- 2.5 terabytes of data
- 1M assessments/month



- Metrics
- Services
- Support

Infrastructure

Program Design

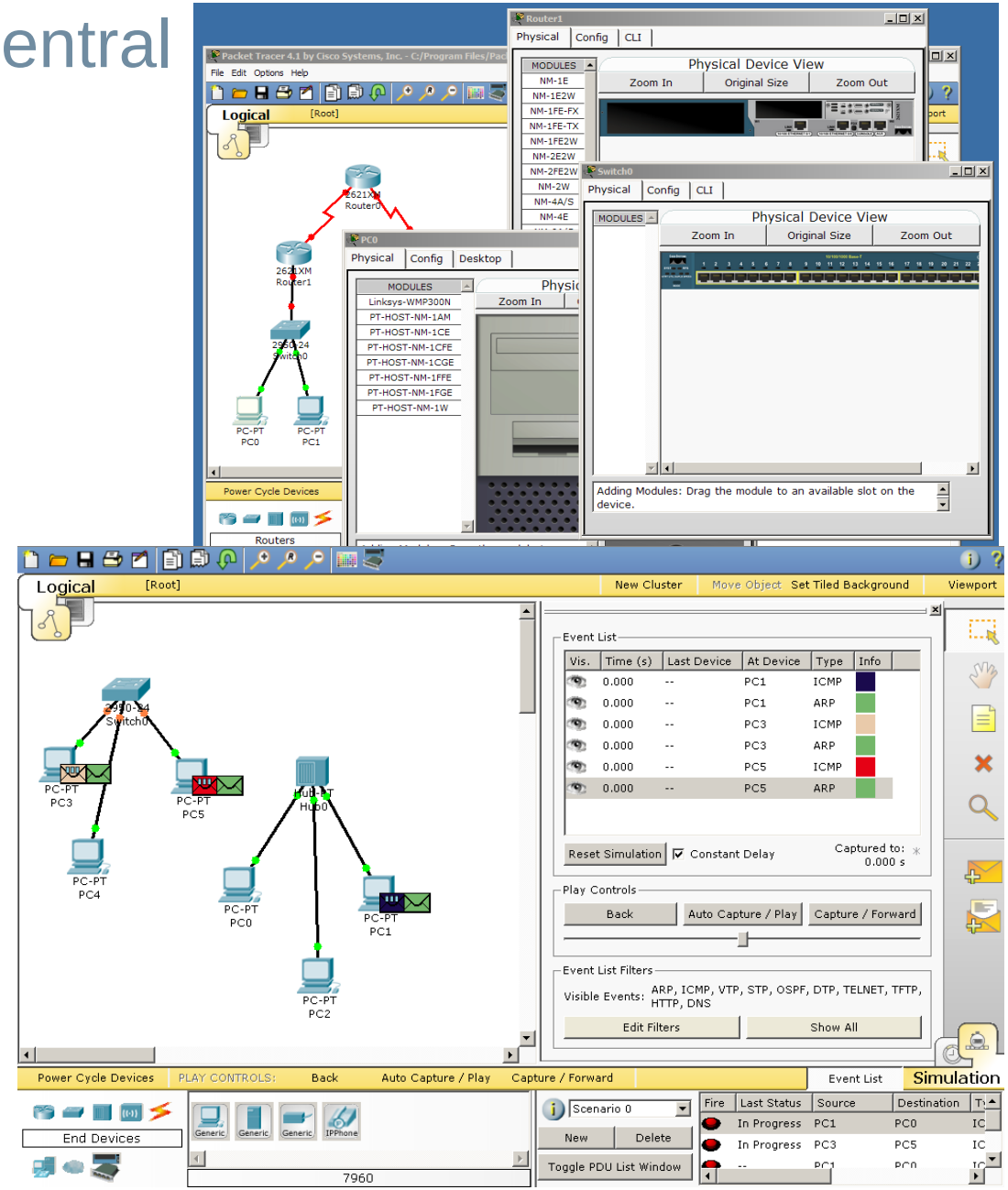


Behrens, J. T., Collison, T. A., & Demark, S. F. (2005) The Seven Cs of comprehensive assessment: Lessons learned from 40 million classroom exams in the Cisco Networking Academy Program. In S. Howell and M. Hricko (Eds.), Online Assessment and Measurement: Case *Studies in Higher Education, K-12 and Corporate*. (pp 229-245). Hershey, PA: Information Science Publishing.

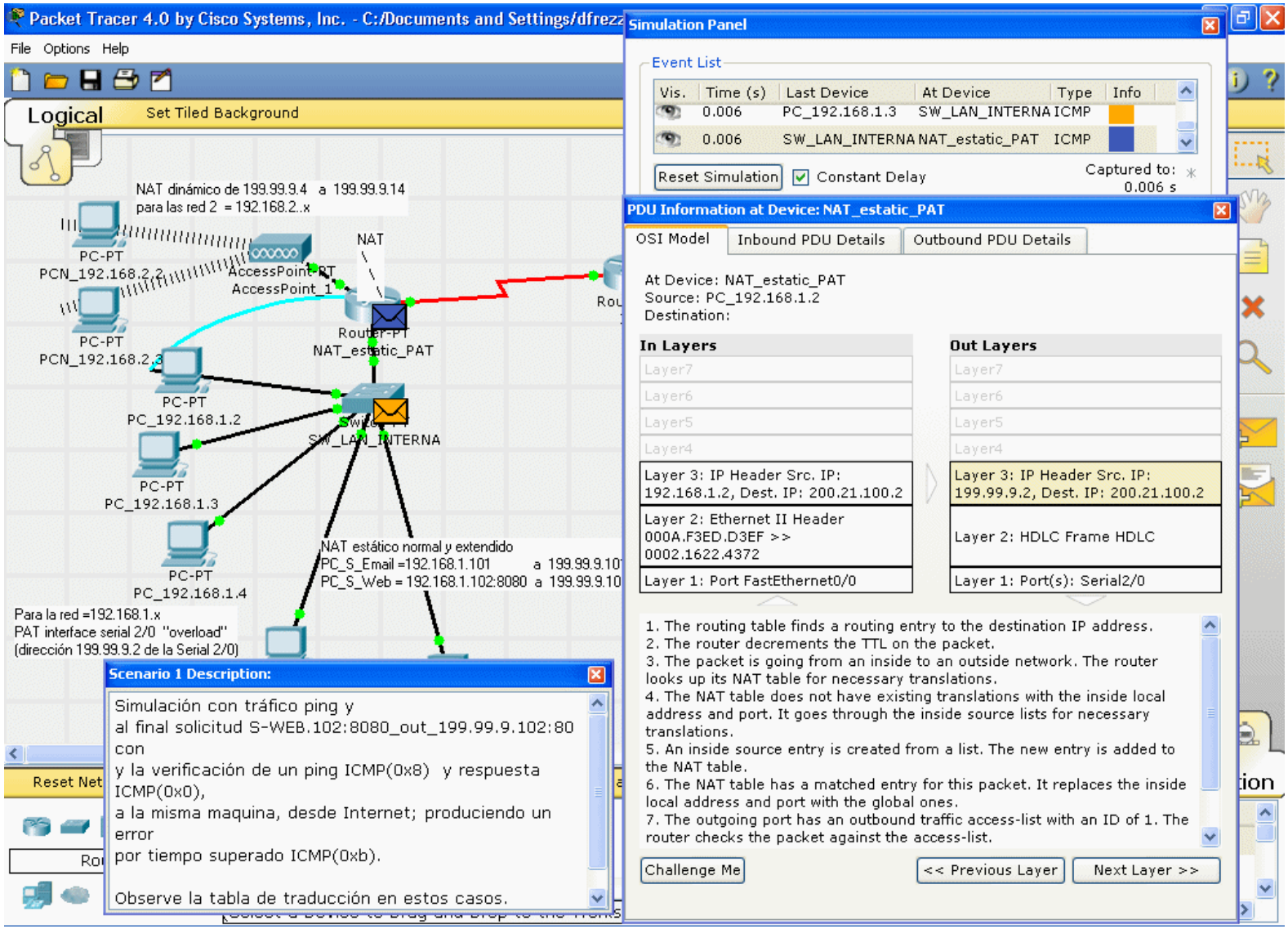
Frezzo, D.C., Behrens, J.T., & Mislevy, R.J. (2009). Activity theory and assessment theory in the design and understanding of the Packet Tracer ecosystem. The International Journal of Learning and Media, 2. http://ijlm.net/knowinganddoing/10.1162/ijlm.2009.0015

Packet Tracer as a central tool for networking education

- **Visualization**
- **Scaling**
- **Rapid revision**
- **Off-line delivery**
- **Complex scoring**
- **Built in gaming**
- **Micro-world authoring**



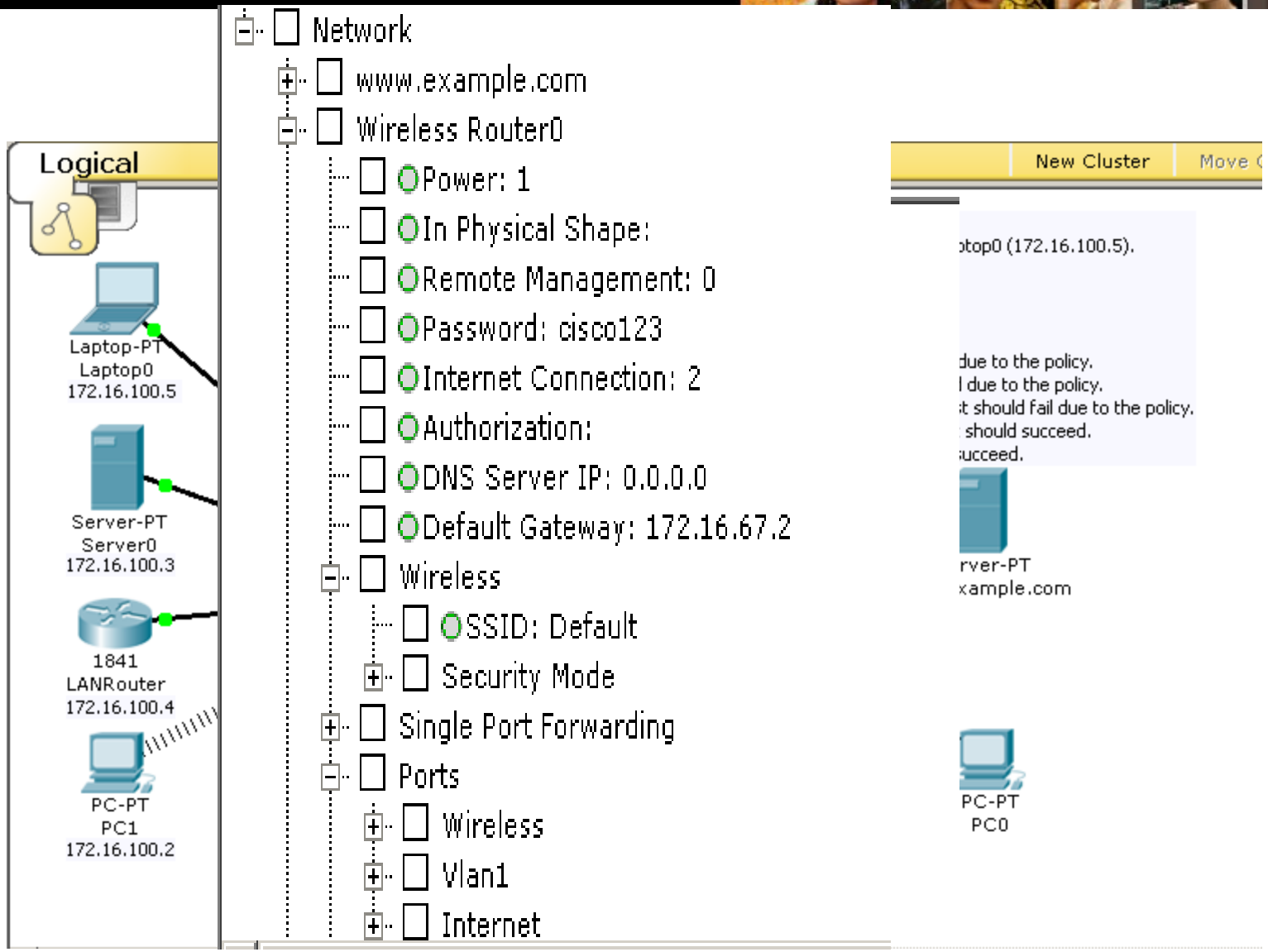
Exploration, Explanation & Experimentation

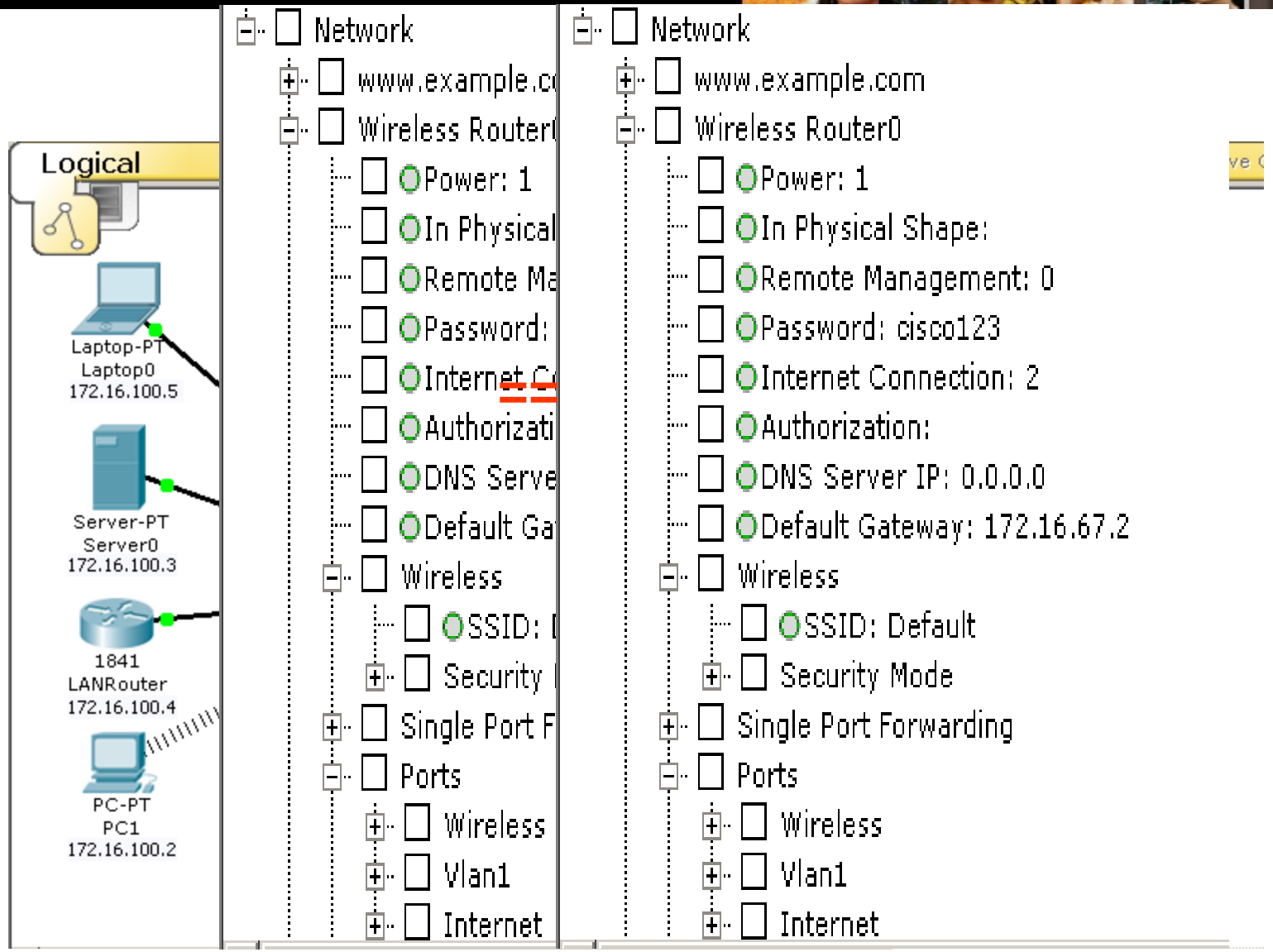


Multiple layers of affordance

Layer	Attributes	Goal
Network Simulation	Interaction with Network Devices Programming Network Devices Behavior of Networks	Create a micro-world with verisimilitude to world of the domain
Interaction Interface	Visualization Interaction	Support understanding & manipulation
Authoring Interface	Edit and save Create stories and micro-worlds Local languages	Re-use and portability Conceptualization & use for explanation
Assessment Interface	Create and save answer networks and related activities	Support micro-worlds for assessment & feedback
Variable manager and macro language	Isomorphic and variant pattern creation. Low level access to data and combination	Support pattern based re-use, flexibility & extensibility

Frezzo, D.C., Behrens, J.T., & Mislevy, R.J. (2009). Design patterns for learning and assessment: facilitating the introduction of a complex simulation-based learning environment into a community of instructors. The Journal of Science Education and Technology. Springer Open Access http://www.springerlink.com/content/566p6g4307405346/





Answer / Feature Network

Student Network

Activity Wizard

Activity Wizard

- Welcome
- Variable Manager
- Instructions
- Answer Network
- Scripting
- Initial Network
- Password
- Test Activity
- Check Activity
- Save
- Exit

Building Answer Network

Show Answer Network

Import/Export

Import File to Answer Network

Export Answer Network to File

Assessment Tree | Connectivity Test | Scoring Model | Overall Feedback | Settings

The Scoring Model provides complete control over constructing activity tasks and providing feedback based on the evidence of the proficiencies.

Work Product Features

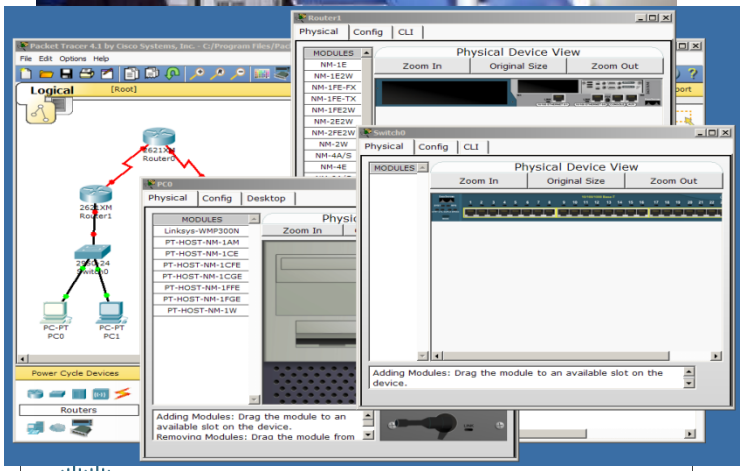
	Name	Expression	Description
1	ISPChoice	AssessmentModel.getAssessmentItemValue("user", "Network:Wireless Router0:Ports:Internet:Link to DSL ModemC	
2	PC0dhcpstate	AssessmentModel.getAssessmentItemValue("user", "Network:PC0:Ports:FastEthernet:DHCP client enable")	
3	PC1dhcpstate	AssessmentModel.getAssessmentItemValue("user", "Network:PC1:Ports:FastEthernet:DHCP client enable")	1 = dhcp 0 = sta
4	PC2dhcpstate	AssessmentModel.getAssessmentItemValue("user", "Network:PC2:Ports:FastEthernet:DHCP client enable")	
5	PC3dhcpstate	AssessmentModel.getAssessmentItemValue("user", "Network:PC3:Ports:FastEthernet:DHCP client enable")	
6	PC0cable	AssessmentModel.getAssessmentItemValue("user", "Network:PC0:Ports:FastEthernet:Link to Wireless Router0:Typ	right type of cab
7	PC3cable	AssessmentModel.getAssessmentItemValue("user", "Network:PC3:Ports:FastEthernet:Link to Wireless Router0:Typ	
8	PC1cable	AssessmentModel.getAssessmentItemValue("user", "Network:PC1:Ports:FastEthernet:Link to Wireless Router0:Typ	
9	PC2cable	AssessmentModel.getAssessmentItemValue("user", "Network:PC2:Ports:FastEthernet:Link to Wireless Router0:Typ	
10	wTimeElapsed	AssessmentModel.getTimeElapsed();	
11	wTimeElapsedinSeconds	wTimeElapsed/1000;	
12	wBonus	10000	bonus points
13	wMaxTime	60000	max time allowe
14	wR0Ip	AssessmentModel.getAssessmentItemValue("user", "Network:Router1:Ports:FastEthernet0/0:IP Address")	
15	wR0Power	AssessmentModel.getAssessmentItemValue("user","Network:Router1:Power")	

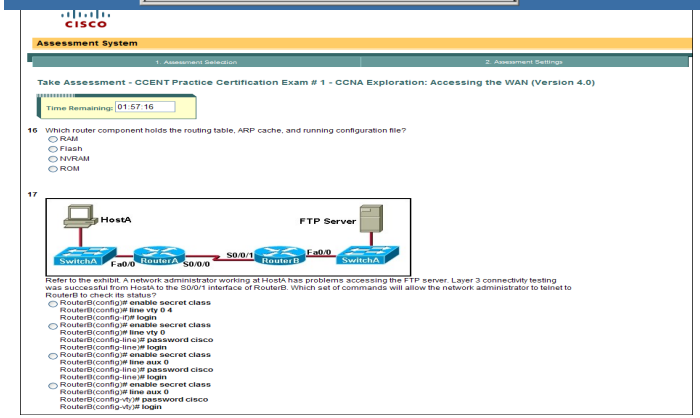
+ | - | Edit | /\ | \/

Scoring Rules

	Type	Name	Expression
1	Primary	ISPChoiceOverall	(ISPChoice == "Connects to Port 1") ? 10 : 2;
2	Primary	PC0movedfromstatic	(PC0dhcpstate == 1) ? 2 : 0;
3	Primary	PC1movedfromstatic	(PC1dhcpstate == 1) ? 2 : 0;
4	Primary	PC2movedfromstatic	(PC2dhcpstate == 1) ? 2 : 0;
5	Primary	PC3movedfromstatic	(PC3dhcpstate == 1) ? 2 : 0;
6	Primary	PC2cabletype	(PC2cable == "0 0") ? 2 : 0;
7	Primary	PC1cabletype	(PC1cable == "0 0") ? 2 : 0;
8	Primary	PC3cabletype	(PC3cable == "0 0") ? 2 : 0;
9	Primary	PC0cabletype	(PC0cable == "0 0") ? 2: 0;
10	Report	CableTypeEval	((PC0cabletype + PC1cabletype + PC2cabletype + PC3cabletype) >= 8) ? "cables correct" : "check your cables"

+ | - | Edit | /\ | \/



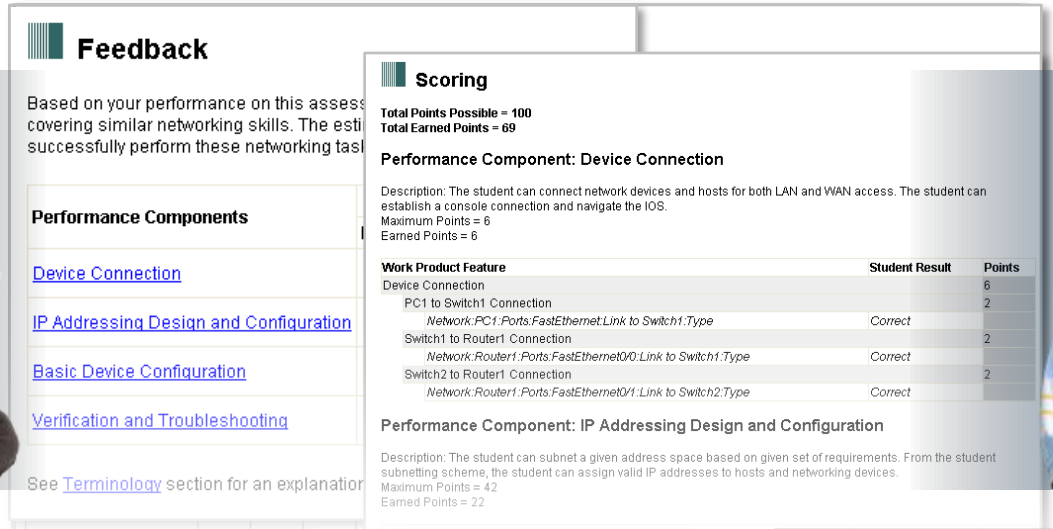


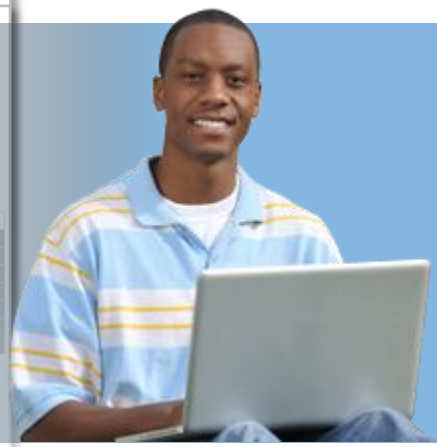
Great for Authenticity; Bad for score consistency, scale and task variation, central analysis

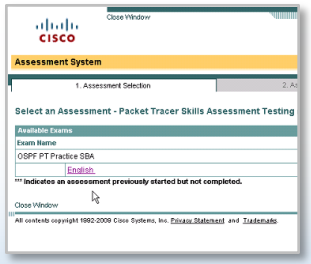
Great for authenticity and local scale; Good for local communication, bad for central analysis

Great for scale, communication (if you want it) and central analysis but weak for authenticity

Using the best of each approach: PT SBA

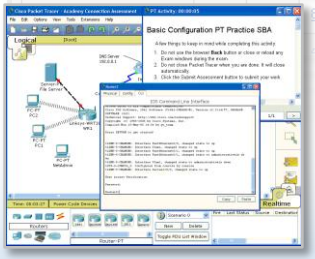






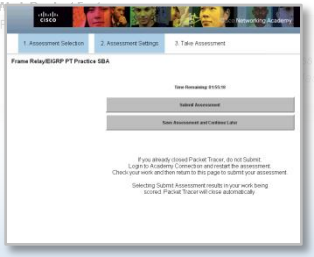
Launch

1



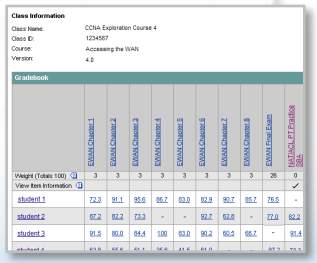
Take Exam

2



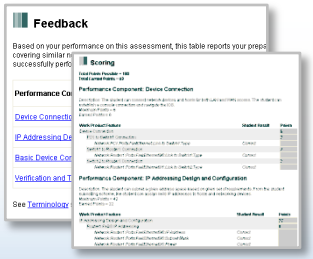
Submit It

3



Automatically Scored

4



View Feedback

5

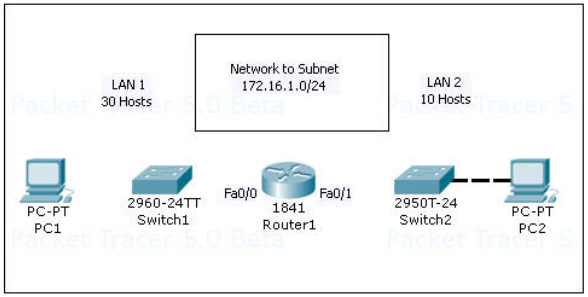
Detailed Environment Provides Detailed Feedback

View Activity

Activity Topology and Instructions

In this section, the initial topology and instructions are shown for review purposes.

Topology



Instructions

Basic Configuration PT Practice SBA

A few things to keep in mind while completing this activity:

1. Do not use the browser **Back** button or close or reload any Exam windows during the exam.
2. Do not close Packet Tracer when you are done. It will close automatically.
3. Click the **Submit Assessment** button to submit your work.

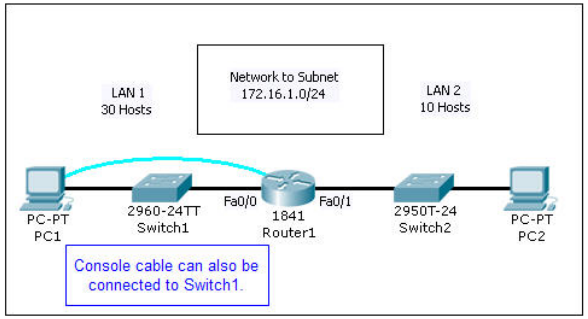
Introduction

In this practice Packet Tracer Skills Exam, you will

View Proposed Solution

Proposed Solution

Answer Topology



Answer Scripts

Router1

```
show run

Building configuration...

Current configuration : 838 bytes
!
version 12.4
no service timestamps log datetime msec
no service timestamps debug datetime msec
```

What we are learning

Overall score related to experience/expertise

Tasks originally too highly constrained and not sufficiently taking account of technical affordances

Use of Packet Tracer throughout curriculum reduces construct-irrelevant variance from interface familiarity

Instructors like it (4.5/5; 94 satisfied or highly satisfied)

Students like it (cust sat = 3.9/5; 74% satisfied or highly satisfied)

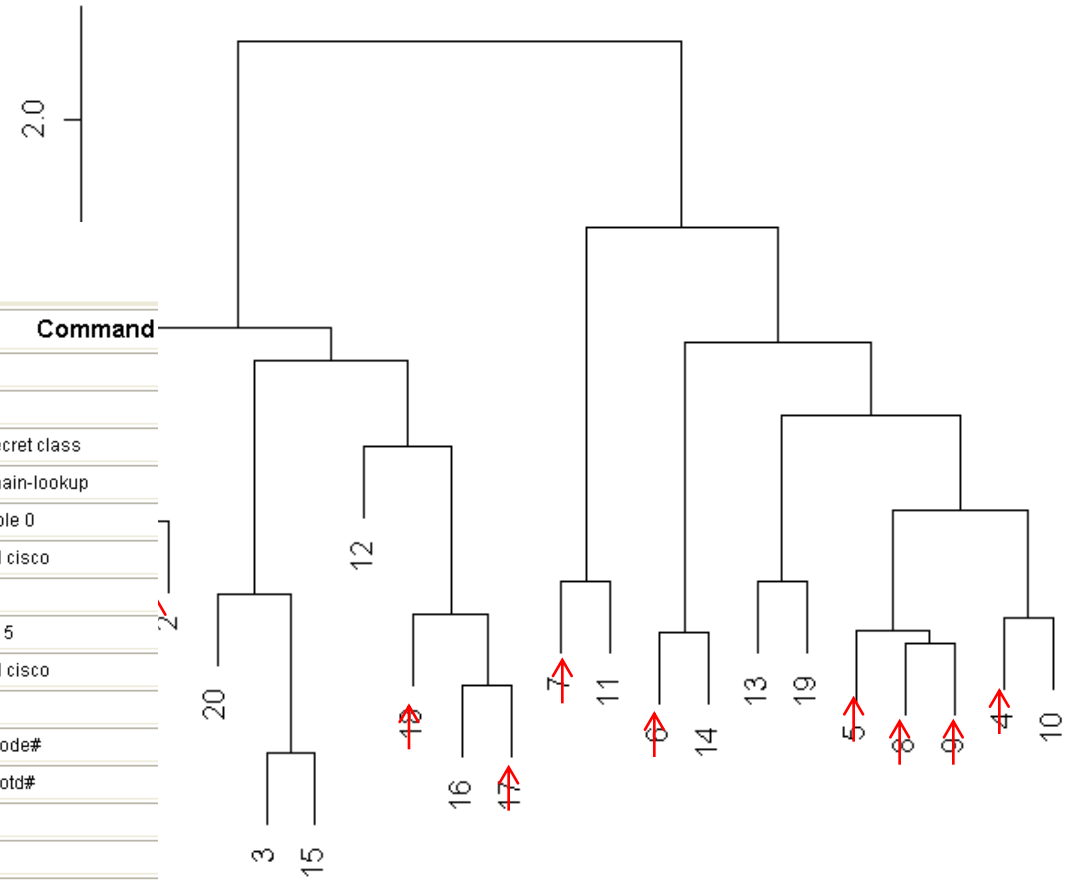
Some students return to it like a game

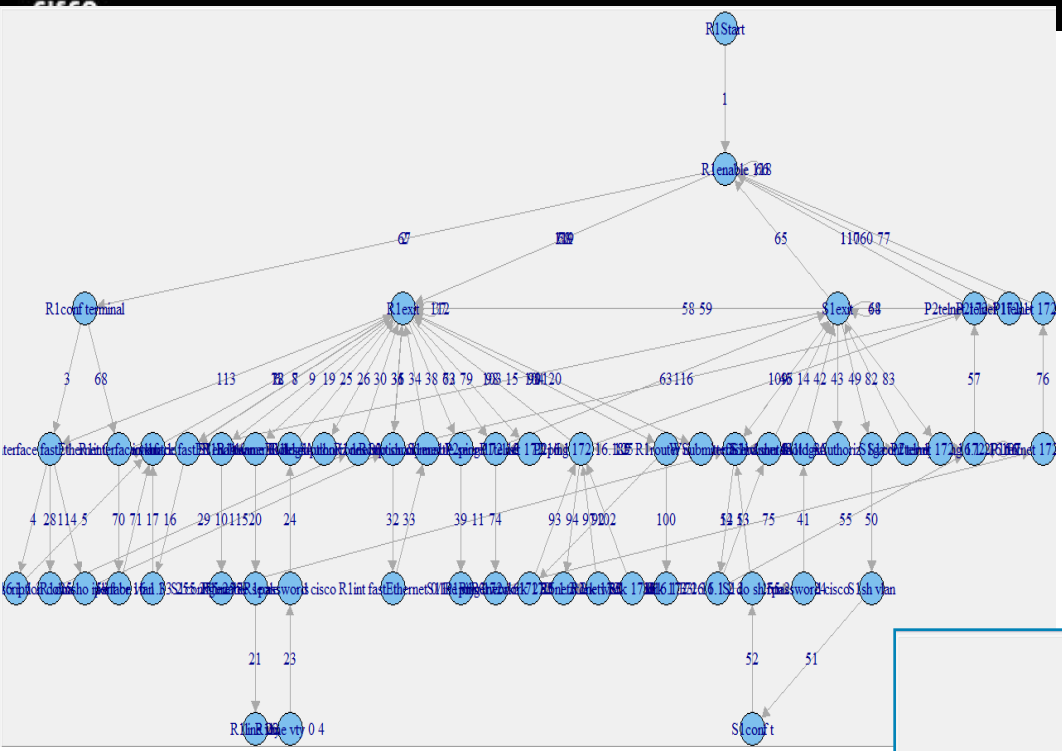
Application of SNLP & Document Retrieval Strategies for stream analysis

- We can see which "documents" are most like other "documents"

Combined Student Log

Timestamp	Device	Prompt	Command
Mon 28. Sep 19:02:34 2009	SW_AC2	Switch>	enable
Mon 28. Sep 19:02:36 2009	SW_AC2	Switch#	conf t
Mon 28. Sep 19:03:55 2009	SW_AC2	Switch(config)#	enable secret class
Mon 28. Sep 19:04:08 2009	SW_AC2	Switch(config)#	no ip domain-lookup
Mon 28. Sep 19:05:55 2009	SW_AC2	Switch(config)#	line console 0
Mon 28. Sep 19:06:00 2009	SW_AC2	Switch(config-line)#	password cisco
Mon 28. Sep 19:06:04 2009	SW_AC2	Switch(config-line)#	login
Mon 28. Sep 19:06:10 2009	SW_AC2	Switch(config-line)#	line vty 0 15
Mon 28. Sep 19:06:16 2009	SW_AC2	Switch(config-line)#	password cisco
Mon 28. Sep 19:06:29 2009	SW_AC2	Switch(config-line)#	login
Mon 28. Sep 19:09:37 2009	SW_AC2	Switch(config-line)#	banner mode#
Mon 28. Sep 19:09:46 2009	SW_AC2	Switch(config-line)#	banner motd#
Mon 28. Sep 19:10:01 2009	SW_AC2	Switch(config-line)#	end
Mon 28. Sep 19:10:06 2009	SW_AC2	Switch#	conf t
Mon 28. Sep 19:10:15 2009	SW_AC2	Switch(config)#	banner motd #
Mon 28. Sep 19:14:23 2009	SW_AC2	Switch(config)#	hostname SW_AC2
Mon 28. Sep 19:15:02 2009	SW_AC2	SW_AC2(config)#	interface vlan 43
Mon 28. Sep 19:16:15 2009	SW_AC2	SW_AC2(config-if)#	ip address 172.16.43.12 255





EDA and visualization

Where to go from here?

PT + Assessment + Game Layer => Aspire

Passport21_Brochure[1].pdf - Adobe Reader

File Edit View Document Tools Window Help

2 / 2 96.9% Find

cisco ASPIRE

OPEN YOUR MIND

Welcome to the World of Cisco Aspire!

Success in the 21st century will depend on your ability to think like an entrepreneur and Aspire is the perfect opportunity to start practicing. As the key decision maker for every networking contract you accept, your primary objective is to complete as many projects as possible. You'll earn credits for every contract you complete and the game ends when you've completed all projects, or when you run out of credits and can no longer afford your expenses. Are you ready to open your mind to the challenges of our competitive global marketplace?

Log In and Select an Avatar
Your journey to entrepreneurship begins when you log in, create a user name and password and then choose an avatar from 16 options. You can start a new game, continue a current one, or use a different avatar you've created.

Utilize Your Mobile Phone
Stay connected to the characters you meet throughout the game with your mobile phone. Aspire teaches you how to make the most of your contacts as prospective clients call you with networking opportunities and new business referrals.

Purchase Your Equipment
Every networking project will require different hardware, software, connections and configurations. You'll find everything you need at the store, but choose wisely to stay within your budget and watch your business grow.

How Far Will You Go?
Aspire tracks your scores, calculates your credits and rates your financial management and business skills. It's a fun way to measure your progress as you complete more projects and develop your entrepreneurial ability.

Networking Opportunities are Everywhere
Aspire helps you identify potential networking contracts with a rotating "C" icon. After you complete a project, a new opportunity will appear at another location on the game board.

Ready for Your First Contract?
Your first project is a small-scale networking contract that gives you a sense of basic game play and interaction. Complete the contract, get paid for your work and check the game board for the next opportunity.

Manage Money Responsibly
The bank plays an important role in cultivating money management skills. You can visit the bank anytime you need to review your transaction history or take out a loan to purchase equipment and supplies.

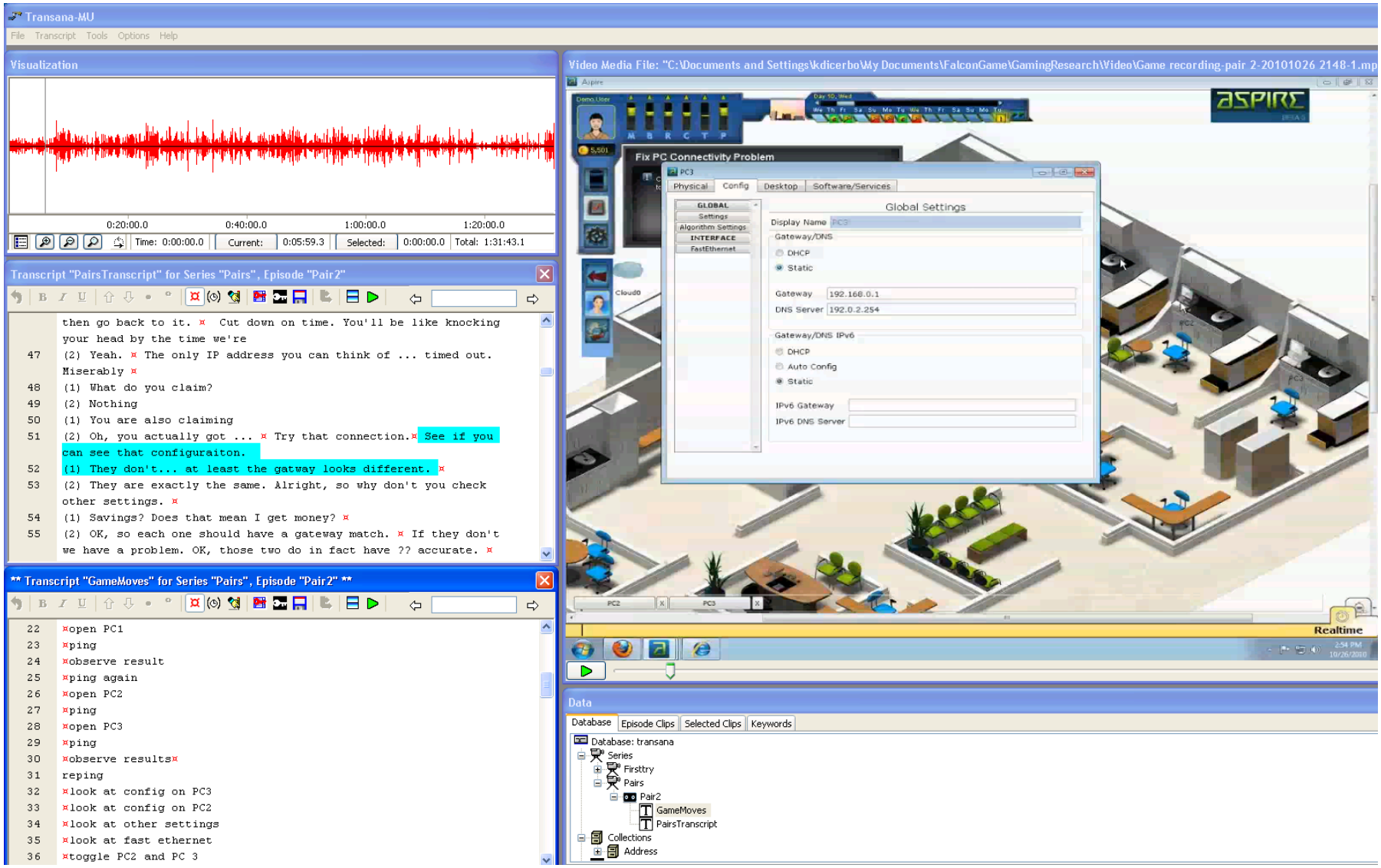
Powerful Networking Simulation
Aspire utilizes a powerful networking simulation and visualization engine based on Cisco Packet Tracer that has been customized and optimized specifically for game play.

Behrens, J. T., Frezzo, D. C., Mislevy, R. J., Kroopnick, M., & Wise, D. (2007). Structural, Functional and Semiotic Symmetries in Simulation-Based Games and Assessments. In E. L. Baker, J. Dickieson, W. Wulfeck, & H. F. O'Neil (Eds.) *Assessment of Problem Solving Using Simulations* (pp. 59-80). New York: Erlbaum.

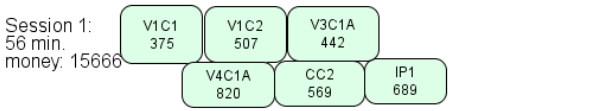
Proficiency Dimension	Example evidence
Business Sense	appropriate choice of new vs. refurbished equipment
Network Configuration	home wireless settings, setting device IP addresses
Money Management	bill payment
Physical Labor	buy & place devices, connect cables
Troubleshooting	diagnose and repair network errors
Reputation	completeness of installation (going beyond minimum)

Demo Here

Pair Video – Coding, Qualitative Analysis

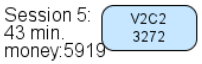


Individual Performance

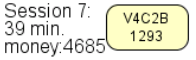


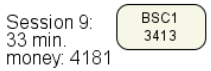
Session 2:
<1 min.
money: 14716
No contracts complete

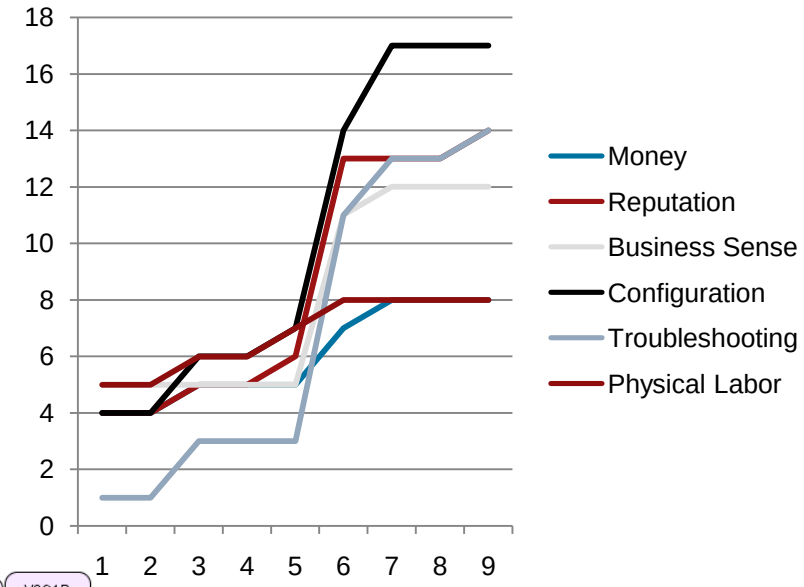
Session 4:
11 min.
money: 9938
No contracts complete



V1C3







V1C3 detail		
Work Product	Max Users	1
Features	Static IP Address on PC3	192.168.0.99
	PC3 is in Network	1
	Connectivity Tested	1
Proficiencies	Business Sense	1
	Configuration	1
	Troubleshooting	1
	Score	300/300

What we are learning

- Students in more advanced classes complete more contracts faster than students in beginning classes
- Learning Process

  Students can be observed trying and discarding potential solutions based on feedback from the game… resulting in new understandings

  The game encourages students to engage in problem solving steps (problem identification, solution generation, solution testing, etc.)

  Common incorrect strategies can be seen across recordings

- Game design

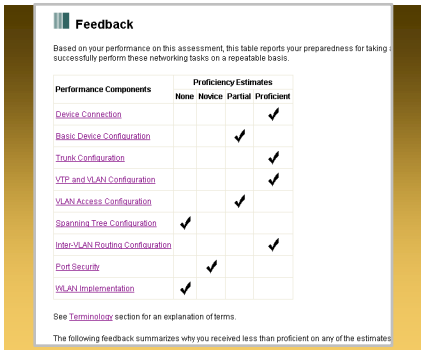
  Additional feedback needed for students after given amount of struggling

  Opportunities to increase information gathering

What does this tell us about assessment?

Curriculum

- Explanatory Text
- Interactive media
- Hands on Labs
- Embedded Assessment
- Rich Feedback
- Simulation supported

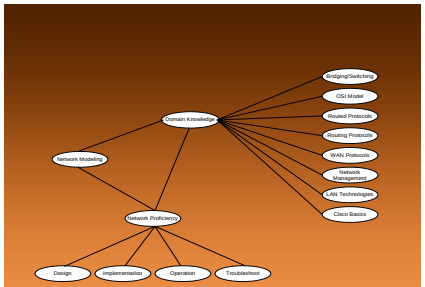


Assessment

- Knowledge focused questions
- Student or instructor initiated
- Integrated reporting
- Rich feedback
- Simulation supported

Gaming

- Promotes motivation and engagement
- Promotes learning and practice
- Provides larger context
- Rich feedback
- Simulation supported



Integration

- Comprehensive skill model provides coherence
- Common use of simulation supports cross-activity transfer
- Possibilities for future research

Conclusion

- Simulation based assessment can be constructed in flexible and scalable ways.
- Good infrastructure does not imply good task or assessment design
- Assessment implementation should be understood in the context of large social and technological ecosystems

And perhaps more important…

- The increasing ubiquity of natural tasks occurring with digital devices opens new worlds of possibility.

- Autopsy → Check up → Unobtrusive natural monitoring

Assessment in the digital ocean

Digital Desert	Digital Ocean
Disconnected intrusions	Ongoing ubiquitous data
Small samples of data	Dramatically large and ubiquitous
Special intrusive systems to get data	Data built into daily activity
Lack of data requires special focused inputs	“Items” no longer exist
Absence of data requires inferential stretch	Availability of data lessons need for inference
Data scarcity leads to small sample science (e.g models of expertise)	Data ocean leads to improved understanding of detailed mechanisms & rules (automated automated scoring)
“Exam” ignorant of your state	Activity starts with access to previous history
Data outside classroom not even considered	Data is data no matter where it is

References

- Behrens, J. T., Mislevy, R. J., DiCerbo, K. E., Rutstein, D. W., & Levy, R. (in press). Evidence Centered Design for Learning and Assessment in the Digital E World. In Mayrath, M., Clarke-Midura, J., Robinson, D. (Eds.). Technology-Based Assessments for 21st Century Skills: Theoretical and Practical Implications from Modern Research.
- Mislevy, R.J., Behrens, J.T., Bennett, R.E., Demark, S.F., Frezzo, D.C., Levy, R., Robinson, D.H., Rutstein, D.W., Shute, V.J., Stanley, K., & Winters, F.I. (2010). On the roles of external knowledge representations in assessment design. Journal of Technology, Learning, and Assessment, 8(2). http://escholarship.bc.edu/jtla/vol8/2
- Frezzo, D.C., Behrens, J.T., & Mislevy, R.J. (2009). Design patterns for learning and assessment: facilitating the introduction of a complex simulation-based learning environment into a community of instructors. The Journal of Science Education and Technology. Springer Open Access http://www.springerlink.com/content/566p6g4307405346/
- Frezzo, D.C., Behrens, J.T., & Mislevy, R.J. (2009). Activity theory and assessment theory in the design and understanding of the Packet Tracer ecosystem. The International Journal of Learning and Media, 2. http://ijlm.net/knowinganddoing/10.1162/ijlm.2009.0015
- Behrens, J. T., Frezzo, D. C., Mislevy, R. J., Kroopnick, M., & Wise, D. (2007). Structural, Functional and Semiotic Symmetries in Simulation-Based Games and Assessments. In E. L. Baker, J. Dickieson, W. Wulfeck, & H. F. O'Neil (Eds.) *Assessment of Problem Solving Using Simulations* (pp. 59-80). New York: Erlbaum.
- Behrens, J. T., Collison, T. A., & Demark, S. F. (2005) The Seven Cs of comprehensive assessment: Lessons learned from 40 million classroom exams in the Cisco Networking Academy Program. In S. Howell and M. Hricko (Eds.)*, Online Assessment and Measurement: Case Studies in Higher Education, K-12 and Corporate*. (pp 229-245). Hershey, PA: Information Science Publishing.
- Levy, R., Behrens, J. T. , & Mislevy, R. J. (2005). Variations in Adaptive Testing and Their On-line Leverage Points. in D. Williams (Ed.) *Online Assessment and Measurement: Emerging Practices, Volume III*. Hershey, PA: IDEA Group
- Behrens, J. T, Mislevy, R. J., Bauer, M., Williamson, D. W., & Levy, R. (2004).Introduction to Evidence Centered Design and lessons learned from its application in a global e-learning program. *International Journal of Testing. 4*, 295-301.
- DeMark, S., & Behrens, J. T. (2004). Using statistical natural language processing for understanding complex responses to free-response tasks. *International Journal of Testing, 4,* 371-390.
- Other articles in this volume of IJT
- Williamson, D. M., Bauer, M., Steinberg, L. S., Mislevy, R. J., & Behrens, J. T, & DeMark, S. F.. (2004). Design rationale for a complex performance assessment. *International Journal of Testing. 4,* 303-332.
- Behrens, J. T. & Yu, C. H. (2003). Exploratory Data Analysis. In J. A. Schinka, & W. F. Velicer, (Eds.). *Handbook of Psychology. Volume II: Research Methods in Psychology*. (pp. 33-64). New York: Wiley & Sons.
- Mislevy, R.J. (1994). Evidence and inference in educational assessment. *Psychometrika, 59,* 439-483.
- Mislevy, R.J. (2006). Cognitive psychology and educational assessment. In R.L. Brennan (Ed.), *Educational Measurement* (Fourth Edition) (pp. 257-305). Phoenix, AZ: Greenwood
- Shute, V. J. (in press 2010). Stealth assessment in computer-based games to support learning. In S. Tobias, & J. D. Fletcher (Eds.), *Computer games and instruction*. Charlotte, NC: Information Age Publishers.