

Knowledge Representations Driving the Design of Computerized Performance Assessments in a Complex Simulated Environment (DRAFT)

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Introduction

- **Cisco Networking Academy Program (CNAP)**
Public Schools-Cisco partnership; Apprentice-level
Design, configuration, troubleshooting of computer networks
10 K instructors, > 100 K students, 150 countries
<http://cisco.netacad.net>
- **Summative “Skills” Performance Exam: An Evolution**
Hands-On cabling and configuration of PCs, switches, routers
“Gold Standard” for Proficiency Evaluation BUT
Uneven psychometric reliability, validity
- **Automated Computerized System: Cisco Network Simulator (CNS)**
Simulation-based, automatically-scored Exams
Successful pilot with Instructors, ongoing design process
- **KRs as Key to Managing Migration Process**
Mislevy describes 5 roles for KRs in Assessment Design
To Improve reliability and validity, KR focus has been crucial

Five Roles of KR in Assessment (Mislevy & Levy, 2005)

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- (Role 1)** An assessment is itself a KR. It makes explicit and sharable the knowledge that is valued, the ways it is used, and the standards of good work.
- (Role 2)** The analysis of any domain in which learning is to be assessed must include the identification and analysis of the KR used in that domain (i.e., the "domain KR").
- (Role 3)** Assessment tasks can be structured around the knowledge, relationships, and uses of domain KR.
- (Role 4)** "Design KR" can be created to organize knowledge about a domain (including its domain KR) in forms that support the design of instruction and assessment. (e.g., knowledge elicitation tools)
- (Role 5)** KR from the disciplines of instructional design and assessment design can guide and structure the domain analyses noted in (2), the task construction noted in (3), and the creation and use of design KR noted in (4).

Role 1: CNS Exam, Assessment as KR

The screenshot shows the Cisco Assessment System interface. At the top, there is a 'Close Window' link and the Cisco Systems logo. Below this is a yellow bar with the text 'Assessment System'. A progress bar indicates three steps: '1. Assessment Selection', '2. Assessment Settings', and '3. Take Assessment'. The main content area is titled 'Assessment' and 'CCNA2 Bridge Skills-Based Assessment'. A red warning message states: 'Once you've completed the simulation activity below, click the "Submit Assessment" button below to submit your work for scoring. WARNING: Don't refresh or re-load this page; don't use the browser's back and forward arrows to leave this page. Doing so will cause the simulation applet to re-initialize, which may cause some of your work to be lost!'. Below the warning, there is a 'Submit Assessment' button and a 'Time Left: 03:37:22' timer. The main task area has three tabs: 'Description Tab', 'Topology Tab', and 'Instruction Tab'. The 'Description Tab' is active and contains the following text: 'Your task is to perform basic IGRP and access control list configuration on a three router network, as pictured on the Topology tab. The following items have been preconfigured on all three routers:'. A bulleted list follows: '• Hostnames on all routers', '• IP addresses and interface descriptions on all interfaces', '• All configured interfaces enabled', '• Clock rates on DCE interfaces', '• The topology cabling', and '• The passwords: console=cisco, secret=class, vty=cisco'. Below the list, it says: 'The following table contains the pertinent preconfiguration information for each router:'. At the bottom, there is a table with tabs for 'Router 1', 'Router 2', 'Router 3', 'Host 1', 'Host 2', and 'Host 3'. The 'Router 1' tab is active and shows the following output: 'System Bootstrap, Version 11.3(2)XA4, RELEASE SOFTWARE (fc1)', 'Copyright (c) 1999 by cisco Systems, Inc.', 'TAC:Home:SW:IOS:Specials for info', 'C2600 platform with 32768 Kbytes of main memory', 'program load complete, entry point: 0x80008000, size: 0x54d718', and 'Self decompressing the image : ##### [OK]'. At the very bottom of the window, there is another 'Close Window' link.

Role 1: Assessments As KR

- **Coordinating Function of the Assessment KR**

Results from a review of curriculum, instructional, assessment
Related to Evidence Centered Design (ECD)

- **Affordances of the Assessment KR**

Usability Engineering principles

Fidelity to real equipment, existing simulations

Translation Issues

- **Usage Guidelines for the Assessment KR**

Need for practice and formative assessment prior to the high-
stakes summative assessment

Reliability and Validity Issues

Role 2: Domain KR's -- Logical Topology, IOS CLI

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Assessment System

1. Assessment Selection 2. Assessment Settings 3. Take Assessment

Assessment

CCNA2 Bridge Skills-Based Assessment

Once you've completed the simulation activity below, click the "Submit Assessment" button below to submit your work for scoring.

WARNING: Don't refresh or re-load this page; don't use the browser's back and forward arrows to leave this page. Doing so will cause the simulation applet to re-initialize, which may cause some of your work to be lost!

Build ferret41 Mon Jan 31 12:53:54 MST 2005 Time Left: 03:36:27

Description Tab Topology Instruction Tab

```
graph TD
    H1[Host 1: 172.16.10.2/24] --- R1[Router 1: Fa0/0 172.16.10.1/24]
    R1 --- R2[Router 2: S0/0 172.16.1.2/24]
    R2 --- R3[Router 3: S0/1 172.16.2.1/24]
    R3 --- H3[Host 3: 172.16.30.2/24]
    R2 --- H2[Host 2: 172.16.20.2/24]
```

Router 1 Router 2 Router 3 Host 1 Host 2 Host 3

```
root processor, part number 0, mask 45
Bridging software.
X.25 software, Version 3.0.0.
1 FastEthernet/IEEE 802.3 interface(s)
2 Serial network interface(s)
32K bytes of non-volatile configuration memory.
8192K bytes of processor board System Flash (Read/Write)

Press RETURN to get started!

User Access Verification
Password: 
```

Role 2: Running Configuration, Student Work Product

```
!
version 12.2
service timestamps debug uptime
service timestamps log uptime
no service password-encryption
!
hostname R1
!
enable secret 5 $1$et8C$eldZF9ubp0+Rw1CCaIr0fw
!
ip subnet-zero
!
!
!
!
!
interface FastEthernet0/0
description R1 LAN
ip address 172.16.10.1 255.255.255.0
half-duplex
!
interface Serial0/0
description WAN link to R2
ip address 172.16.1.1 255.255.255.0
clockrate 56000
!
interface Serial0/1
no ip address
shutdown
!
!
router igmp 1
network 172.16.0.0
!
ip classless
no ip http server
!
!
line con 0
exec-timeout 0 0
password cisco
login
line aux 0
line vty 0 4
password cisco
login
!
end
```

Router R2

Role 2: Importance of Domain KRs

- **Logical Topology**

Crucial KR throughout computer networking

Basis for many other KRs

- **Internetwork Operating System (IOS) Command Line Interface (CLI)**

Crucial KR for controlling the behavior of networking devices

Leads to dialogs between students and simulated devices

- **Router Running Configuration**

Primary work product of student taking a CNS assessment

- **Limitations and Challenges Associated with Domain KRs**

Fidelity to real networking equipment “limited” BUT

Computers allow KRs and KR interactions impossible with real equipment, with real instructors in finite amount of time

Validity Issues

Role 3: Item Information Page 1 (IIP 1)

Item Information Page - Microsoft Internet Explorer

File Edit View Favorites Tools Help

Address <http://assessment.netacad.net/servlet/org.cli.delivery.rendering.servlet.IIPServlet/LMSID=CNAMS,Theme=ccna3theme,Style=ccna3,Language=en,Version=2,C> Go

Google Search Web Search Site PageRank AutoFill Options

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Item Information Page - Total Score

Below you will find the question as it was presented during the exam and the scoring rules associated with the item. Because this item is provided by an external assessment subsystem, student responses are not available for viewing.

General Information

Name = Skills-Based Final

Student-Model Variables

SMV Name = Total Score
Maximum Score = 11

Feedback

- Review the methods of constructing named access lists. After the access list is named, the format is to deny a protocol followed by source address, destination address, and finally the part of the protocol to be denied.
- You have a complete understanding of enabling the IGRP routing protocol and the publishing of the correct active networks.
- Please review the interface to which you have assigned the access list as well as the direction in which it is applied.

Solution (Running Configurations)

Router R1

```
!  
version 12.2  
service timestamps debug uptime  
service timestamps log uptime  
no service password-encryption  
!  
hostname R1  
!  
enable secret 5 $1$et80$e1dZF9ubp0+Rw1CCaIr0fw  
!  
ip subnet-zero  
!  
!  
!  
!
```

Done Internet

Role 3: Item Information Page 2 (IIP 2)

Item Information Page - Microsoft Internet Explorer

Address: http://assessment.netacad.net/ser/vlet/org.cli.delivery.rend

Search Web Search Site PageRank AutoFill

Links Customize Links Free Hotmail Windows Free AOL & Unlimited Internet MSN Web Events Customize Links Original Free

Search the Web Search Address http://sandles.unicon.net:200/GetItemInformation.action?SESSION_ID=22303

```
interface Serial0/0
no ip address
shutdown
!
interface Serial0/1
description WAN link to R2
ip address 172.16.2.2 255.255.255.0
!
!
router igrp 1
network 172.16.0.0
!
ip classless
no ip http server
!
!
line con 0
exec-timeout 0 0
password cisco
login
line aux 0
line vty 0 4
password cisco
login
!
end
```

Combined User Log

```
00:00:32 R3 00:00:32: %LINK-3-UPDOWN: Interface FastEthernet0/0, changed state to up
00:00:32 R1 00:00:32: %LINK-3-UPDOWN: Interface FastEthernet0/0, changed state to up
00:00:41 R1 00:00:32: %LINEPROTO-5-UPDOWN: Line protocol on Interface FastEthernet0/0
00:00:43 R1 Password:
00:00:45 R1 R1>en
00:00:47 R1 Password:
00:00:55 R1 R1#confit t
00:00:55 R1 ^
00:00:55 R1 % Invalid input detected at '^' marker.
00:00:59 R1 R1#config t
00:00:59 R1 Enter configuration commands, one per line. End with CNTL/Z.
00:01:03 R1 R1(config)#router rip
00:01:13 R1 R1(config-router)#network 172.16.0.0
00:01:16 R1 R1(config-router)#^Z
00:01:19 R1 R1#
```

Scoring Rule For: Routing Protocol Observable

Measures how well students do at configuring RIP and IGRP routing protocols.

| | |
|---------------|------------------|
| Max Value = 6 | Earned Value = 6 |
|---------------|------------------|

Scoring Rule For: Access List Application Observable

Measures how well students do at assigning ACLs to appropriate interfaces.

| | |
|---------------|------------------|
| Max Value = 1 | Earned Value = 0 |
|---------------|------------------|

Scoring Rule For: Access List Definition Observable

Measures how well students do at defining correct ACLs.

| | |
|---------------|------------------|
| Max Value = 4 | Earned Value = 0 |
|---------------|------------------|

Close Window

Role 3: KRs in the Assessment as “Reasoning From Evidence”/ECD Process

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- **Item Information Pages – Including Instructors in the Process**
 - IIP 1 – Student Model Variables, Feedback, Work Product
 - IIP 2 – Rubrics, Scoring Rules, Observables
- **Router Running Configuration** (static, final work product)
 - Primary mediating artifact for instructor-student assessment interactions
- **Hybrid Approach: Hands-on AND CNS**
 - Divide and Conquer: retain aspects of hands-on performance assessment while automating other aspects
 - Reliability and Validity Issues
- **Limitations of Static Work Product**
 - Instead analyze LOG files of student-simulator dialog?

Role 4: Design Pattern, Network Troubleshooting

(Wise, 2005)

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| | |
|--------------------------------|--|
| Characteristic features | <p>Initial state with an error</p> <p>Final state with error removed Symptoms must be gathered</p> <p>Error isolated using layered approach</p> <p>Solution expressed in programming language</p> |
| Variable features | <p>Types of error and layer of the error</p> <p>Difficulty in tracking down the error</p> <p>Difficulty in fixing the error</p> <p>Length of time given;</p> <p>Hardware and software tool availability;</p> |

Role 4: Design KR's

- **From the Need for Parallel Forms, to Design Patterns**

To provide practice and security for high-stakes performance assessment, we need multiple parallel forms

Desire to design parallel forms converged with our research on design patterns and task templates

- **From the Need for Parallel Forms, to the Need for an Authoring Environment**

Creating multiple forms currently is tedious for SMEs and programming-intensive

We need easy-to-use tool to implement design patterns, task templates, families of activities, activity banks

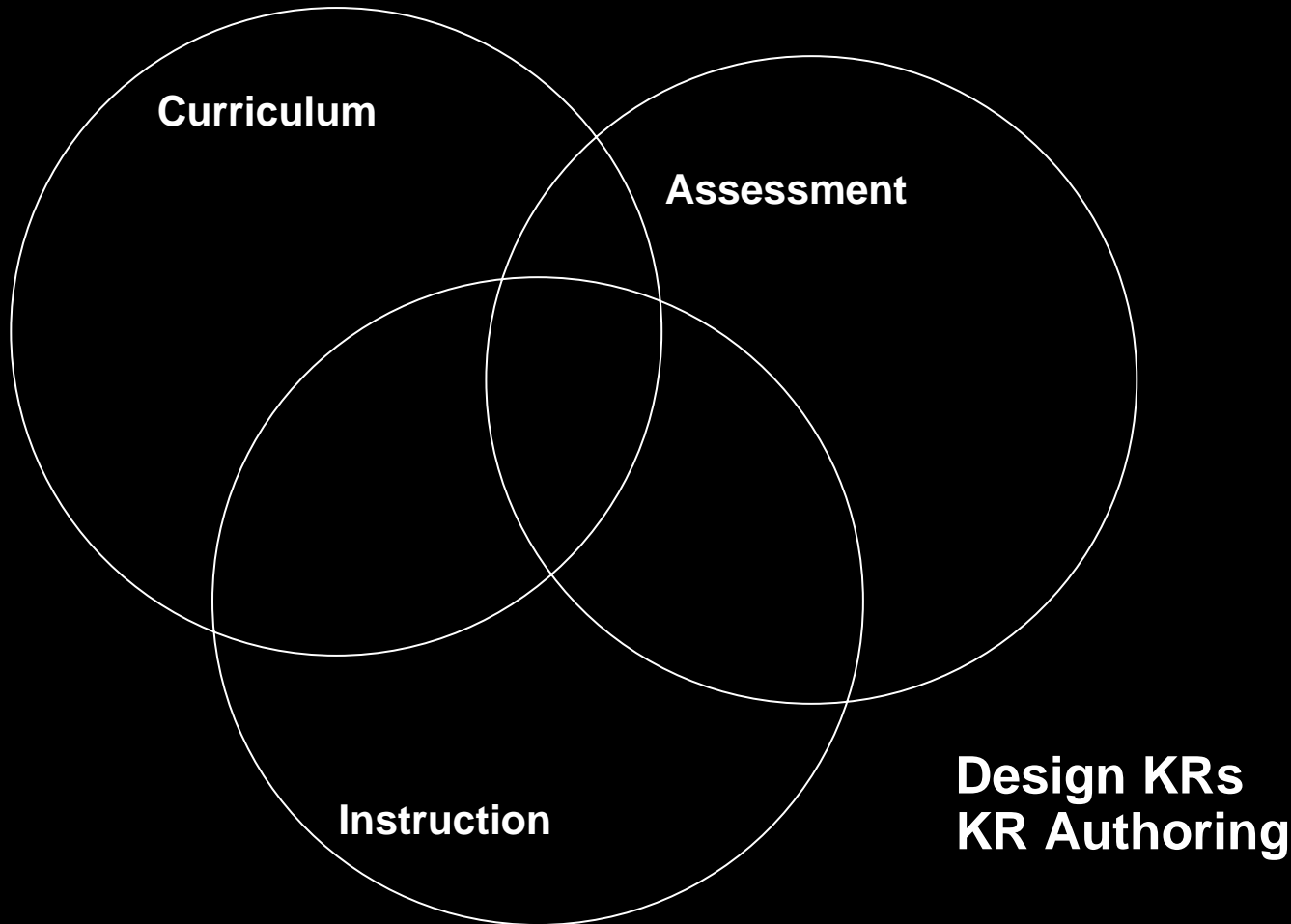
- **Design Patterns of Interest**

Network Design, Implementation, and Troubleshooting

Role 5: KR Management/Coordination Role

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Reliable and Valid Assessment ↔ “Navigational Fix”



Role 5: Interactive KRs

Scenario 0

TIME: 1

PC0 >> PC1

Layer 7: <User data>
Layer 6
Layer 5
Layer 4: Sequence # = 34232
Layer 3: 11.0.0.2 >> 10.0.0.2
TTL = 32
Protocol = ICMP
Layer 2: 00e0.f7fe.9712
>> 00e0.f964.9258
Layer 1: Port 0

| Type | Network | Port | Next Hop IP | Metric |
|------|------------|------|-------------|--------|
| C | 1.0.0.0/8 | 1/0 | -- | 0/0 |
| C | 10.0.0.0/8 | 0/0 | -- | 0/0 |
| R | 11.0.0.0/8 | 1/0 | 1.1.1.2 | 120/1 |

```
PC0 --- 0/0 --- Router 0 --- 1/0 --- Router 1 --- 0/0 --- PC1
```

```

N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
E1 - OSPF external type 1, E2 - OSPF external type 2, E - EGP
i - IS-IS, L1 - IS-IS level-1, L2 - IS-IS level-2, ia - IS-IS inter area
* - candidate default, U - per-user static route, o - ODR
P - periodic downloaded static route
Gateway of last resort is not set

C 1.0.0.0/8 is directly connected, FastEthernet1/0
R 10.0.0.0/8 [120/1] via 1.1.1.1, FastEthernet1/0
C 11.0.0.0/8 is directly connected, FastEthernet0/0
Router 0#sh ip route
Codes: C - connected, S - static, I - IGRP, R - RIP, M - mobile, B - BGP
D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
E1 - OSPF external type 1, E2 - OSPF external type 2, E - EGP
i - IS-IS, L1 - IS-IS level-1, L2 - IS-IS level-2, ia - IS-IS inter area
* - candidate default, U - per-user static route, o - ODR
P - periodic downloaded static route

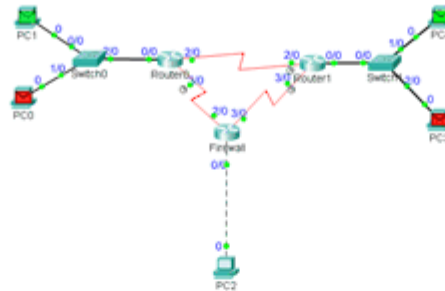
```

Network Description

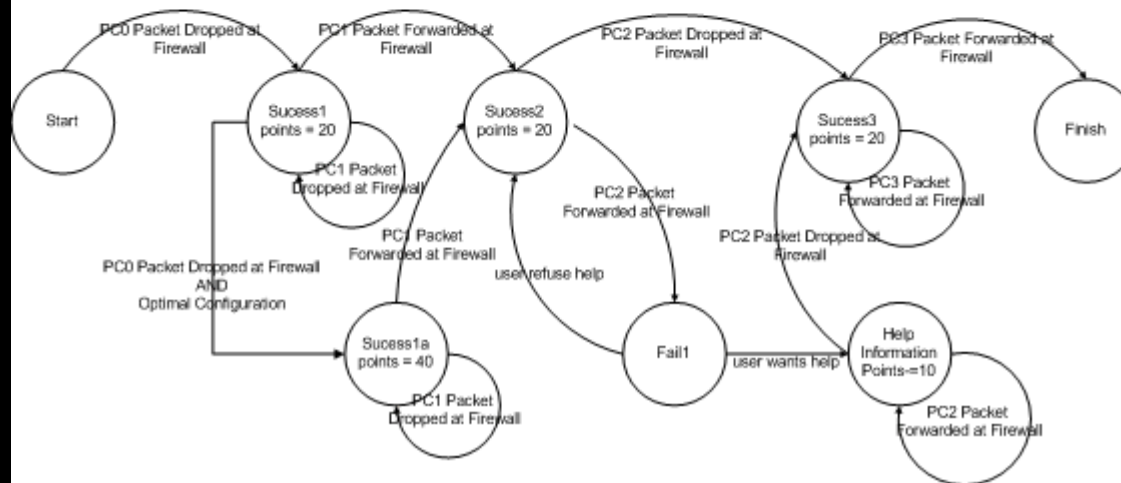
This is the simplest routed network. In addition to the logical topology and physical link status indicators, the command line interface representation, OSI model representation, routing table representation, and movie-controlled animated packet representation are present.

Role 5: FSD Activity Authoring

FSD: Packet Tracer v4.0
Game-Like Activity



Example Activity: Create access-lists on "Firewall" to allow the green packets to pass to PC2 and the red packets to drop.



Role 5: Various Sources of KRs

- **Assessment as a “Navigational Fix”**

Coordination of KRs for CNS as analogous to Hutchins’ description of distributed cognition in *Cognition in the Wild*

- **Packet Tracer**

General Purpose Simulation, Animation, Visualization Software

Universally distributed in CNAP

Expanding of Packet Tracer KRs

- **Finite State Diagram (FSD) Authoring?**

FSDs are ubiquitous in electronics, robotics, programming, game design

Proposed use for authoring instructional & assessment activities

Conclusions and Future Work

- **Instructor Data on CNS: Positive**

Instructor Feedback lead to many design changes

- **Student Data: Soon**

CNS (summative assessment) offered to students in next few months

Packet Tracer (practice environment) already in use

- **KRs as Key to Managing Reliability and Validity**

5 Roles Driving Design Process

- **Question/Comments?**

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Thank You.

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