INTERNETWORKING

PURPOSE
To evaluate each contestant's preparation for employment and to recognize outstanding students for excellence and professionalism in the field of internetworking.

First, download and review the General Regulations at: http://updates.skillsusa.org.

ELIGIBILITY
Open to all active SkillsUSA members enrolled in a computer networking training program with internetworking as the occupational goal.

CLOTHING REQUIREMENT
Class E: Contest specific — Business Casual
For men: Official SkillsUSA white polo shirt, black dress slacks, black socks, black leather shoes.
For women: Official SkillsUSA white polo shirt with black dress skirt (knee-length) or black slacks; black socks or black or skin-tone seamless hose; black leather dress shoes.

These regulations refer to clothing items that are pictured and described at: www.skillsusastore.org. If you have questions about clothing or other logo items, call 800-401-1560 or 703-956-3723.

Note: Contestants must wear their official contest clothing to the contest orientation meeting.

EQUIPMENT AND MATERIALS
1. Supplied by the technical committee:
   a. Computer workstation for the written portion of the contest
   b. Cisco routers, switches and equipment not listed as supplied by the contestant
2. Supplied by contestant:
   a. Copper cable terminating tools (punchdown tool and crimpers cable stripper, DB9 to RJ45)
   b. Cable tester
   c. Laptop computer with wireless, Ethernet connection and COM port (USB with adapter)
   d. All competitors must create a one-page résumé and submit a hard copy to the technical committee chair at orientation. Failure to do so will result in a 10-point penalty.

   Note: Your contest may also require a hard copy of your résumé as part of the actual contest. Check the Contest Guidelines and/or the updates page on the SkillsUSA website: http://updates.skillsusa.org.

SCOPE OF THE CONTEST
The contest is defined by industry standards as set by the current industry technical standards. The contest will consist of three parts: a troubleshooting problem, an online written test and end to end networking hands-on evaluation. Assume it is a normal week for an IT expert.

Knowledge Performance
The contest will include an online written knowledge exam assessing knowledge of general networking concepts.

Skill Performance
The contest may include but is not limited to the following assessments:

1. **Design problem** — The network design problem, as formulated by the national technical committee, assesses a student's ability to design functionality, scalability, adaptability and manageability of an internetworking system. The problem is built into each activity the competitor does in the three days of the contest. Competitors may not see a specific topic design, but they are being scored on how their knowledge of network design makes the tasks easier for them.

2. **Hands-on evaluation** — The hands-on evaluation component of the contest tests a student's ability to professionally design, install and maintain internetworks. Given a set of networking equipment (cable, fiber, hubs/switches routers, etc.), the student

must, in a finite amount of time, install or repair a network and demonstrate that the installation properly runs internet applications.
Given a logical topology and network requirements, the students will be able to develop a usable network that meets or exceeds the documentation provided. The vision and context is that client companies would request a demonstration booth that runs a particular internet application, and the student, given equipment and tools, would provide the appropriate connectivity for the application to run successfully.

3. **Technical Assistance Call** — The student must solve a networking problem while on the phone with a customer. This is a simulation of working in a Technical Assistance Center.

4. **Written Exam** — The student must answer questions related to CCNA-level networking.

Standards and Competencies

WORK 1.0 — Explain common networking concepts and terminology

1.1 Identify the basic characteristics of LANs and WANs
1.2 Explain the concept of bandwidth and throughput and factors that affect them
1.3 List and describe the components necessary to create a small LAN using wire or wireless media
1.4 Identify the roles of various network devices in a network (NICs, hubs, switches, routers, firewalls, AP)
1.5 Explain the concept of latency and how it can be minimized
1.6 Describe the advantages and disadvantages associated with implementing common physical topologies: star/extended star, ring and mesh
1.7 Explain the importance of implementing basic security in computer networks

WORK 2.0 — Install and troubleshoot basic hardware and software required to communicate in a simple network and test for connectivity

2.1 Identify the pin-outs and construct a UTP (patch, console and crossover) cable for connectivity
2.2 Specify the cable type required for the various Ethernet connections
2.3 Configure a host with the appropriate addressing parameters to connect to a network
2.4 Verify and troubleshoot basic connectivity using various testing tools, utilities and commands (cable testers, ping, trace, IP configuration, etc.)
2.5 Document the physical and logical aspects of network topology
2.6 Determine and install the appropriate network cabling and media required for connectivity between devices
2.7 Configure, connect, verify and troubleshoot issues with the operation of an Ethernet NIC
2.8 Determine the physical issues associated with cabling network equipment working over a WAN link
2.9 Configure wireless appliances as needed in an office or in a meshed environment

WORK 3.0 — Compare and contrast various types of media used for networking

3.1 Explain the characteristics and benefits of copper cable, fiber and wireless network media (air) in network applications, including data transmission speeds
3.2 Identify the basic characteristics of UTP and fiber cables
3.3 Identify Ethernet cabling issues that can cause degraded service
3.4 Explain practical factors that cause attenuation of data signals over the different network media types (copper, fiber, air [radio frequency], and identify possible solutions to a media problem
3.5 Identify basic concerns of implementing faster Ethernet

WORK 4.0 — Explain the fundamental concepts associated with media access techniques (Ethernet operation, MAC, LLC, CSMA/CD)

4.1 Describe the differences between full duplex and half duplex transmissions
  4.1.1 Describe media access considerations of each
4.2 Explain the function of auto negotiation of speed and duplex
4.3 Describe the function of the Data Link Layer as it applies to Ethernet, including MAC and LLC sublayers
4.4 Explain the concept of broadcast media and the addressing of a layer 2 broadcast on an Ethernet media
4.5 Describe and discuss CSMA/CD, including the process, listen, send, collision, jam and back off

WORK 5.0 — Optimize network design in regard to segmentation, collision domains and broadcast domains

5.1 Describe basic operation of hubs and repeaters as they apply to Ethernet
5.2 Explain how collisions are detected and managed in Ethernet networks
5.3 Explain the concepts of collision domains and network segmentation
5.4 Explain the benefits of using a switch versus using a hub in an Ethernet network
5.5 Explain how collisions and excessive broadcasts occur in networks
  5.5.1 Identify devices used to minimize collision and excessive broadcast effects

WORK 6.0 — Implement and correct problems associated with basic IP addressing and sub netting schemes

6.1 Explain the purpose of an IP address, subnet mask and a default gateway
  6.1.1 Identify the appropriate address required for internetwork communication between hosts
6.2 Categorize the different IP v4 address classes and their identifying features
6.3 Explain the advantages and disadvantages of using public and private IP v4 addresses
6.4 Determine whether an IP address is a network, broadcast, subnet, public or private IP v4 address
6.5 Determine the appropriate subnet mask and IP addressing scheme required to meet network requirements for scalability and functionality
6.6 Identify the methods for a node to obtain an IP address (include static and dynamic methods)
6.7 Correct common problems associated with implementing basic IP addressing schemes in a network environment
6.8 Contrast IP v4 with IP v6

WORK 7.0 — Describe fundamental concepts of switching and routing

7.1 Explain the major functions of a switch
7.2 Explain the major functions of a router
7.3 Explain the basic use of routed and routing protocols in network
7.4 Describe the forwarding of frames and packets in switched and routed networks
7.5 Describe the characteristics and functions of IP (connectionless and unreliable)
7.6 Compare the basic concepts of static and dynamic routing
7.7 Explain the OSI model and its functionality in computer networking

WORK 8.0 — Define the Layers of the OSI model

8.1 Explain the benefits of using the OSI model as a conceptual framework for network communication
8.2 Explain the process of encapsulation and identify the protocol data units associated with each OSI Layer model
8.3 Identify and describe the functions of network devices at each layer of the OSI model
8.4 Explain ARP and when it is used
8.5 Compare and contrast connection and connectionless delivery of packets in a network
8.6 Describe the primary functions of the transport layer
8.7 Compare and contrast characteristics of TCP and UDP
8.8 Identify and describe the major TCP/IP protocols used at each layer of the OSI model
8.9 Identify basic issues that occur at each layer using the OSI model
  8.9.1 Identify the fields in the headers of protocol data units

8.9.2 Describe their role in propagating data in a network (MAC address, IP address, TCP port number)

WORK 9.0 — Describe the importance of a router in a WAN configuration

9.1 Compare WAN connections to LAN connections
9.2 Identify the role of a router in a WAN
9.3 Describe the importance of a WAN router
9.4 Describe router physical characteristics
9.5 Connect all router external connections, management, LAN and WAN

WORK 10.0 — Configure a router to multiple networks by using the IOS software

10.1 Identify the workings of an operating system works with the router
10.2 Determine the state of the router interfaces using the LED indicators
10.3 Identify the features of the IOS for services that will be delivered on the network

WORK 11.0 — Log in to a router, record the IOS and running configuration and use troubleshooting commands

11.1 Describe the boot process
11.2 Log in and navigate throughout the router IOS
11.3 Fix errors by using troubleshooting command line errors
11.4 View the image names and memory of the router by using the show version command 6

WORK 12.0 — Configure a router and switch utilizing the CLI

12.1 Use CLI command modes
12.2 Configure a host names
12.3 Configure passwords
12.4 Use the show commands
12.5 Configure interfaces
12.6 Change configurations
12.7 Configure interface descriptions
12.8 Configure login banners and MOTD
12.9 Configure host tables
12.10 Back up the configuration file by using the copy command to back up the configuration file
12.11 Configure spanning tree

WORK 13.0 — Discover other devices on the network using the router

13.1 Document neighboring routers and Cisco devices by using Cisco Discovery Protocol (CDP) commands
13.2 Monitor CDP
13.3 Disable CDP
13.4 Troubleshoot CDP
13.5 Gather information about remote devices by using Telnet
13.6 Establish and verify a Telnet connection
13.7 Disconnect and suspend Telnet sessions
13.8 Use advanced Telnet operation
13.9 Troubleshoot IP address issues

WORK 14.0 — Manage the IOS software

14.1 Identify where a Cisco device locates and loads IOS
14.2 Use the boot system command
14.3 Configure the register
14.4 Troubleshoot IOS boot failure
14.5 Manage the Cisco file system
14.6 Identify IOS naming conventions
14.7 Use TFTP to manage and copy

WORK 15.0 — Configure routing protocols

15.1 Identify the workings of a static route
15.2 Configure static routes
15.3 Configure default route forwarding
15.4 Verify static route configuration
15.5 Troubleshoot static route configuration
15.6 Identify the purpose of a routing protocol and autonomous system
15.7 Identify the classes of routing protocols
15.8 Identify distance vector routing protocol features and examples
15.9 Discuss link-state routing protocol features and examples
15.10 Describe path determination
15.11 Configure EIGRP, RIPv2 and OSPF single- and multi-area

WORK 16.0 — Identify and use distance vector routing protocols

16.1 View distance vector routing updates, hold-down timers, and RIP processes
16.2 Eliminate routing loops through split horizon, route poisoning, triggered updates
16.3 Use RIP as the routing protocol
16.4 Configure RIP
16.5 Use the IP classless command

16.6 Verify RIP configuration
16.7 Troubleshoot RIP update issues
16.8 Load balance using RIP
16.9 Load balance across multiple paths
16.10 Integrate static routes with RIP

WORK 17.0 — Use TCP/IP suite error and control messages to troubleshoot a router

17.1 Identify TCP/IP error message
17.2 Use ICMP
17.3 Use ICMP message delivery
17.4 Discover unreachable networks
17.5 Use ping to test destination reach ability
17.6 Define echo messages
17.7 Use the TCP/IP suite control messages
17.8 Use ICMP redirect/change request
17.9 Use requests and reply message formats
17.10 Use congestion and flow control message
17.11 Configure QoS and Nbar to control congestion

WORK 18.0 — Use basic show commands to troubleshoot the router

18.1 Use the show IP route command to determine the gateway of last resort, route source and destination, L2 and L3 addresses, administrative distance, route metric, the route next hop, last route update and multiple paths to destination
18.2 Identify OSI layers
18.3 Troubleshoot Layer 1 using show interface
18.4 Troubleshoot Layer 2 using show interface
18.5 Troubleshoot using show CDP
18.6 Troubleshoot using trace route
18.7 Troubleshoot routing issues
18.8 Troubleshoot using show controllers serial
18.9 Use the debug command

WORK 19.0 — Identify the intermediate TCP/IP operations and porting

19.1 Identify synchronization process or three-way handshake
19.2 Define a denial-of-service attack
19.3 Identify how windowing, sequencing numbers and positive ACK work together to deliver data packets
19.4 Compare UDP with TCP
19.5 Observe transport layer ports
19.6 Test multiple conversations between hosts
19.7 Define ports for services, clients and numbering and well-known port numbers
19.8 Compare and contrast MAC addresses, IP addresses and port numbers

WORK 20.0 — Identify and use access control lists (ACLs) to add security to the network

20.1 Describe access control list fundamentals
20.2 Create ACLs
20.3 Discuss the function of a wildcard mask
20.4 Use an ACL by Verify
20.5 Compare standard, extended ACLs and named ACLs
20.6 Place an ACL to create the requested security inside a firewall

WORK 21.0 — Define and use variable length subnet masking (VLSM)

21.1 Define VLSM and why is it used
21.2 Recognize when to use VLSM
21.3 Calculate subnets with VLSM
21.4 Recognize route aggregation with VLSM
21.5 Configure VLSM on a multi-router network

WORK 22.0 — Describe how RIP Version 2 is incorporated in a routed network

22.1 Compare RIP v1 and v2
22.2 Configure RIP v2
22.3 Verify RIP v2
22.4 Troubleshoot RIP v2

WORK 23.0 — Understand how to design and implement single-area and multi-area OSPF

23.1 Recognize link-state routing protocol
23.2 Compare the advantages and disadvantages of link-state routing
23.3 Compare and contrast distance vector and link-state routing
23.4 Compare OSPF with distance vector routing protocols
23.5 Observe single-area OSPF configuration
23.6 Configure the OSPF routing process
23.7 Configure OSPF loopback address and router priority
23.8 Modify OSPF cost metric
23.9 Configure OSPF authentication
23.10 Configure OSPF timers

23.11 Verify the OSPF configuration
23.12 Troubleshoot OSPF configuration

WORK 24.0 — Describe and implement EIGRP routing protocol

24.1 Recognize EIGRP concepts
24.2 Describe EIGRP concepts and terminology
24.3 Configure EIGRP
24.4 Configure EIGRP summarization
24.5 Verify basic EIGRP
24.6 Troubleshoot EIGRP configuration

WORK 25.0 — Understand how switching operates as well as switching concepts

25.1 Recognize Ethernet/802.3 LAN technologies
25.2 Recognize factors that affect network performance
25.3 Recognize network segmentation using hardware devices
25.4 Recognize basic operations of a switch
25.5 Compare Layer 2 and Layer 3 switching
25.6 Compare symmetric and asymmetric switching
25.7 Recognize micro segmentation implementation
25.8 Recognize the effects switches have on a collision domain

WORK 26.0 — Understand the use of the access, distribution and core layers in switching and routing

26.1 Describe LAN design goals
26.2 Use a 1,2,3 layered model in the switch design

WORK 27.0 — Understand how to do a complete switch configuration

27.1 Verify port LEDs during switch POST
27.2 View initial boot output from the switch
27.3 Examine keyboard help in the switch CLI
27.4 Recognize switch modes
27.5 Configure the switch
27.6 Verify the catalyst switch default configuration
27.7 Configure the catalyst switch
27.8 Manage the MAC address table
27.9 Configure static MAC addresses
27.10 Configure port security
27.11 Execute a plan for adds, moves and changes
27.12 Manage switch operating system
27.13 Define password recover
27.14 Recognize firmware upgrade

WORK 28.0 — Understand how spanning tree protocol has an effect on network design and setup

28.1 Describe redundant topologies
28.2 Describe a broadcast storm
28.3 Recognize redundant topology and spanning tree
28.4 Describe spanning tree operations
28.5 Design the configuration to select a root bridge
28.6 Select the stages of spanning tree port states
28.7 Describe spanning tree recalculation and its effects on the network

WORK 29.0 — Describe how virtual LANs help to control broadcast domains and how this benefits the LAN network

29.1 Recognize VLAN concepts
29.2 Demonstrate the relationship between broadcast domains with VLANs and routers
29.3 Describe VLAN types

WORK 30.0 — Configure a VLAN-using network design concept

30.1 Define geographic VLANs
30.2 Configure static VLANs
30.3 Verify VLAN configuration
30.4 Save VLAN configuration
30.5 Delete VLANs
30.6 Troubleshoot VLANS

WORK 31.0 — Use virtual trunking protocol to set up multiple ports on a router and switch

31.1 Describe Trunking concepts
31.2 Describe Trunking operation
31.3 Describe VTP concepts and how to configure and implement them in a physical and logical network design
31.4 Divide physical interfaces into sub-interfaces
31.5 Configure inter-VLAN routing

WORK 32.0 — Demonstrate how to use NAT and PAT to scale IP addresses over a multi-network configuration

32.1 Name the private address spaces
32.2 Identify the features of NAT and PAT
32.3 Configure NAT and PAT

32.4 Verify PAT configuration
32.5 Troubleshoot NAT and PAT configurations
32.6 Identify and use DHCP in a router configuration
32.7 Verify DHCP operation
32.8 Troubleshoot DHCP

WORK 33.0 — Recognize the use of WAN technologies in the configuration of a router and the delivery of data

33.1 Name the WAN devices
33.2 Identify WAN standards and encapsulation types
33.3 Compare packet and circuit switching
33.4 Name the WAN link options and technology related to them
33.5 Incorporate WAN design into the network scheme
33.6 Know how to identify and select networking capabilities
33.7 Use a three-layer design model

WORK 34.0 — Understand and configure a secure PPP serial connection

34.1 Define serial point-to-point links
34.2 Define time-division multiplexing
34.3 Use demarcation point as a reference for security
34.4 Define DTE-DCE
34.5 Compare HDLC encapsulation to PPP
34.6 Configure PPP authentication
34.7 Compare password authentication Protocol (PAP) to challenge handshake authentication protocol
34.8 Configure PPP
34.9 Verify the serial PPP encapsulation configuration
34.10 Troubleshoot the serial PPP encapsulation configuration

WORK 35.0 — Network Systems Administration

35.1 Installation, configuration, and management of Windows workstation software
35.2 Installation, configuration, and management of Windows Server software
35.3 Installation, configuration and management of LINUX software
35.4 Installation and configuration Network Services
35.5 Installation, configuration and management of Virtualized Environments

WORK 36.0 — Configure a point-to-point and multi-point Frame Relay circuit

36.1 Describe frame relay concepts
36.2 Define frame relay terminology
36.3 Configure a basic frame relay
36.4 Configure a static frame relay map
36.5 Configure frame relay sub-interfaces
36.6 Verify the frame relay configuration
36.7 Troubleshoot frame relay configuration

WORK 37.0 — Demonstrate best practices of network administration

37.1 Define and compare workstations and servers
37.2 Define NOS
37.3 Use network operating systems Microsoft Windows 7,8,10, VM, and LINUX versions as they relate to a network
37.4 Describe SNMP and CMIP standards
37.5 Configure SNMP and use syslogs to monitor networks

WORK 38.0 — Provide customer support

38.1 Converse effectively and correctly with a customer
38.2 Speak clearly and to the point when conversing about products and solutions for the customer
38.3 Repeat name, location and phone number back to the customer during technical support conversations
38.4 Record all conversations with customers as either information, need to know or solution delivered
38.5 Make good comparisons that the customer can relate to when troubleshooting a problem
38.6 Take the needed actions to fix the customer's problem
38.7 Close the conversation with a positive, reassuring attitude

Committee Identified Academic Skills

The technical committee has identified that the following academic skills are embedded in this contest.

Math Skills

- Use fractions to solve practical problems
- Use proportions and ratios to solve practical problems
- Use scientific notation
- Solve practical problems involving percents
- Solve single variable algebraic expressions
- Measure angles
- Find surface area and perimeter of two-dimensional objects
- Find volume and surface area of three-dimensional objects
- Make predictions using knowledge of probability
- Make comparisons, predictions, and inferences using graphs and charts
- Organize and describe data using matrixes
- Solve problems using proportions, formulas and functions
- Binary number systems
- Bolean logic functions

Science Skills

- Plan and conduct a scientific investigation
- Describe characteristics of types of matter based on physical and chemical properties
- Use knowledge of physical properties (shape, density, solubility, odor, melting point, boiling point and color)
- Understand the modern model of atomic structure
- Use knowledge of classification of elements as metals, metalloids and nonmetals
- Describe phases of matter
- Use knowledge of potential and kinetic energy
- Use knowledge of mechanical, chemical and electrical energy
- Use knowledge of heat, light and sound energy
- Use knowledge of sound and technological applications of sound waves
- Use knowledge of the nature and technological applications of light
- Use knowledge of principles of electricity and magnetism
- Use knowledge of static electricity, current electricity and circuits

Language Arts Skills

- Provide information in oral presentations
- Demonstrate use of such verbal communication skills as word choice, pitch, feeling, tone and voice
- Demonstrate use of such nonverbal communication skills as eye contact, posture and gestures using interviewing techniques to gain information
- Demonstrate comprehension of a variety of informational texts
- Understand source, viewpoint and purpose of texts
- Demonstrate knowledge of appropriate reference materials
- Use print, electronic databases and online resources to access information in books and articles
- Demonstrate informational writing

Connections to National Standards

State-level academic curriculum specialists identified the following connections to national academic standards.

Math Standards

- Numbers and operations
- Problem solving
- Reasoning and proof
- Communication
- Connections
- Representation

Source: NCTM Principles and Standards for School Mathematics. For more information, visit: www.nctm.org.

Science Standards

- Understands the sources and properties of energy
- Understands forces and motion
- Understands the nature of scientific inquiry

Source: McREL compendium of national science standards. To view and search the compendium, visit: http://www2.mcrel.org/compendium/browse.asp.

Language Arts Standards

- Students apply a wide range of strategies to comprehend, interpret, evaluate and appreciate texts. They draw on their prior experience, their interactions with other readers and writers, their knowledge of word meaning and of other texts, their word identification strategies and their understanding of textual features (e.g., sound-letter correspondence, sentence structure, context, graphics)
- Students adjust their use of spoken, written and visual language (e.g., conventions, style, vocabulary) to communicate effectively with a variety of audiences and for different purposes
- Students employ a wide range of strategies as they write and use different writing process elements appropriately to communicate with different audiences for a variety of purposes
- Students use spoken, written and visual language to accomplish their own purposes (e.g., for learning, enjoyment, persuasion and the exchange of information)

Source: IRA/NCTE Standards for the English Language Arts. To view the standards, visit: www.ncte.org/standards.