



## What's a CLI?

- Command Line Interface
- A command language is the part of the CLI with which the user interacts
- An interface used to configure most routers & servers
- \$78 billion of router & server hardware is sold each year, compared to \$187 billion in PC sales

(Gartner Inc, 2002 a, b, c)



# Pros and Cons of CLIs

## Pros

- **Efficient.** Combine commands and don't hunt through the GUI
- **Fast.** Text transmissions consume almost no network bandwidth
- **Flexible.** Write scripts to automate repetitive tasks
- **What many want.** Real geeks don't use GUIs

## Cons

- CLIs rely on recall memory while GUIs rely recognition memory
- Recognition memory is almost 3 times more accurate and almost 2 times faster than recall memory (Nobel, 2001)



Command Language Design

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# CLI Examples

```
Console
-----
Sun Microsystems Inc. SunOS 5.8 Generic February 2000

***          This machine runs Solaris 8          ***
***          Problems should be reported to IS    ***
***          ***

gosling@lachok119: chad 777 CLI_issues2.txt
gosling@lachok119: █
```

UNIX

```
Cisco IOS
-----
Router#show dhcp ?
lease show DHCP Addresses leased from a server
server show DHCP Servers we know about

Router#show dhcp server
DHCP Proxy Client Status:
lease: 0
offer: 0 Requests: 0
Declines: 0 Releases: 0

Router#_
```

Cisco IOS

```
Konsole <2>
-----
[vszacc:/O1/app/oracle] svrmgr1
Oracle Server Manager Release 3.1.7.0.0 - Production
Copyright (c) 1997, 1999, Oracle Corporation. All Rights Reserved.
Oracle® Enterprise Edition Release 8.1.7.4.0 - Production
JServer Release 8.1.7.4.0 - Production

SVRMGR> connect r5/r5;
Connected.
SVRMGR> select user_id,dm_id,usr_name from user;
USER_ID DM_ID USER_NAME
-----
1 root
1 row selected.
SVRMGR> exit
Server Manager complete.
[vszacc:/O1/app/oracle] █
```

SQL

```
Command Prompt
-----
Microsoft(R) Windows NT(TM)
(C) Copyright 1985-1996 Microsoft Corp.

C:\WINDOWS>mb
The name specified is not recognized as an
internal or external command, operable program or batch file.

C:\WINDOWS>md
The syntax of the command is incorrect.

C:\WINDOWS>md CLI_FOLDER

C:\WINDOWS>_
```

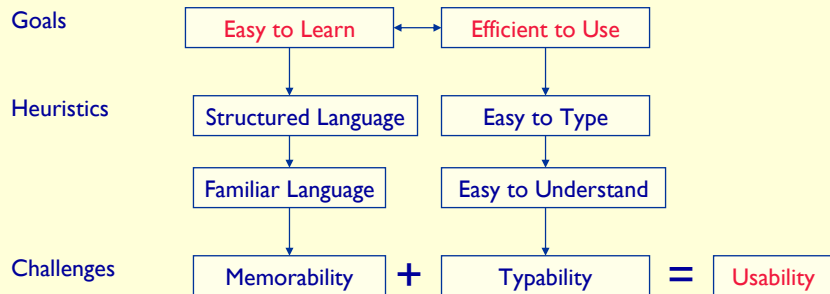
MS-DOS



Command Language Design

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# Goals, Heuristics, & Challenges



Heuristics often compete, so you have to find the best trade off



# Heuristics: Structure & Familiarity

## Structured Language

1. Balance power & simplicity
2. Use a hierarchical structure
3. Define rules & follow them
5. Model the industry standard

- Use parallel words
- Use the imperative mood
- If inconsistent, do not model

## Familiar Language

4. Model English
  - Use words, not symbols
  - Use familiar punctuation
6. Use meaningful words
7. Use shorter commands
8. Allow full command words
9. Use distinct words



# Heuristics: Typing & Understanding

## Easy to Type

10. Abbreviate with truncation
11. Be case-insensitive
12. Avoid shift keys



## Easy to Understand

13. Give positive feedback
14. Ask for confirmation
15. Use rich error messages
16. Provide meaningful help



# I. Balance Power & Simplicity

Among UNIX experts, 5% of commands (20/400) accounted for 70% of those used (Kraut, 1983)

## • Power

Many command words

```
add-user  
delete-user  
edit-user
```

Example:

```
edit-user larry moe
```

*Less to type, more to remember*

## • Simplicity

Few command words

```
add-user  
delete-user
```

Example:

```
delete-user larry  
add-user moe
```

*More to type, less to remember*

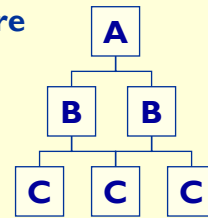


## 2. Use a Hierarchical Structure

### A recursive tree-like information structure

#### Research:

- Free recall 2–3 times more accurate (Bower, 1969)
- 63% fewer recall & problem-solving errors (Carroll, 1982)

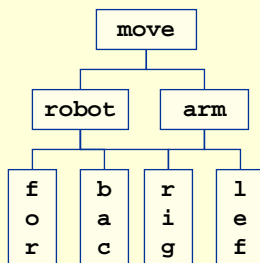


#### Value:

- Encourages deep levels of processing
- Each level is a mnemonic cue for the next
- Requires fewer command words



## 2. Use a Hierarchical Structure



#### ✓ Do

move robot	forward
" "	backward
" "	right
" "	left
move arm	forward
" "	backward
" "	right
" "	left

#### ✗ Don't

advance
retreat
right
left
raise
lower
swing-out
swing-in



## 3. Define Rules & Follow Them

### Research:

- UNIX error rates 3%–50% by command
- High error rates for non-standard syntax (Kraut, 1983)

### Example:

- 1–3 command words per command  
Min: **exit** Max: **show ip statistics**
- 0–3 parameters per command  
Min: **exit** Max: **add host host\_ip host\_name port\_num**
- Unique first 2 letters for each command word  
Do: **show** / **exit** Don't: **show** / **shutdown**
- Default values for most parameters



## 4. Model English: Overview

- Use words instead of symbols
- Use familiar punctuation
- Use parallel words
- Use the imperative mood with a verb > object structure
- Do not model English if it's inconsistent



## 4. Model English: Research

### Compared an English-like text editor with a notational editor:

replace "go" with "gone" vs. `rs:/go/,/gone/`

- Included novice and experienced users
- 76% more tasks completed with the English-like editor
- 49% fewer errors made
- All users preferred the English-like editor after using it
- Experienced users who preferred a notational editor before the study changed their minds after

(Ledgard, 1980)



## 4. Model English: Words & Punctuation

	✓ Do	✗ Don't
Use words	<code>show file</code>	<code>ls</code>
	<code>delete file</code>	<code>rm</code>
Avoid symbols	<code>delete file all</code>	<code>rm *</code>
Use familiar punctuation	<code>replace 'go' with 'gone'</code>	<code>rs:/go/,/gone/</code>
	<code>add record</code>	<code>add.record;</code>



## 4. Model English: Use the Imperative

Tell your computer what to do:

~~Subject~~ > Verb > Object

- **English Language**

Go!  
Help!  
Add sugar.  
Find the book.

- **Command Language**

exit  
help  
add route  
find file

- **× Don't**

route add



## 4. Model English: Use Parallel Words

- Make related command words semantically & grammatically parallel
- 7 times more errors when nonparallel words were used (Carroll, 1982)

- **✓ Do**

enable ipsec  
disable ipsec  
  
insert record  
delete record

- **× Don't**

ipsec on  
disable ipsec  
  
add record  
kill record





## 4. Model English: Unless Inconsistent

- Task time, number of errors, number of help requests significantly reduced with consistent but non-English syntax (Barnard, 1981)

### ✓ Do

search message file

save message ref

delete message digit

### ✗ Don't

search for file in message

save message as ref

delete digit from message



## 5. Model the Industry Standard

- Balance against other heuristics
- Cisco has 57% of the router market (Gartner Inc, 2002 a)
- Cisco IOS is close to an industry standard
- Follows many heuristics
- Doesn't always follow verb > object order

```
Cisco - Hypertext Terminal
Router#show dhcp ?
lease Show DHCP Addresses leased from a server
server Show DHCP Servers we know about

Router#show dhcp server
DHCP Proxy Client Status:
DHCP server: ANY (255.255.255.255)
Expires: 0
OKExpires: 0 Requests: 0 Ackns: 0 Naks: 0
Declines: 0 Releases: 0 Bads: 0

Router#_
Connected 0:03:31 Auto detect 9600 B&N-1 DORSL GPRS NUM Date Print echo
```



## 6. Use Meaningful Words

- Meaningful words are easier to remember
- Avoid jargon unless your users think in jargon

### ✓ Do

`add`  
`accounting`  
`user-name`

### ✗ Don't

`concatenate`  
`radius`  
`network-access-identifier`



## 7. Use Shorter Commands

- Short-term memory is limited:  $7 \pm 2$  (Miller, 1956)
- Can you pronounce it in under 1.5 seconds? (Schweickert, 1986)
- Shorter commands are easier to remember
- Shorter commands are faster to type

### ✓ Do

`map phone-number`  
`add subnet`

### ✗ Don't

`add phone-number mapping record`  
`add ip assigned address range`



## 8. Allow Full Command Words

- When given a choice, 37% of users never abbreviate (Benbasat, 1984)
- If the full word was not known, users forgot twice as many abbreviations (Grudin, 1985)

✓ **Do**

move

remove

copy

✗ **Don't**

mv

rm

cp



## 9. Use Distinct Words

- Words that look similar are difficult to read
- Words that sound similar are easy to confuse
- Words with similar typing patterns are easy to mistype (motor patterns for common words interfere with others)
- Words that start the same are difficult to abbreviate with truncation

✓ **Do**

send

find

choose

✗ **Don't**

send

search

select



## 10. Abbreviate with Truncation

- Having an abbreviation rule improves recall
- Users recall more with a rule than when they make up their own abbreviations
- Simple truncation is the most effective rule, especially for encoding (Ehrenreich, 1985)
- Well-known acronyms can be used instead of words

✓ Do		✗ Don't
ethernet	eth	ethrnt or ethr
show	s	shw or sw
delete	del	dlt
ppp	ppp	point-to-point-protocol



## 11. Be Case-Insensitive / 12. Avoid Shift Keys

- Case differences are hard to remember  
IPSec or IPSEC or ipsec? eMail or email or e-mail?
- Shifted characters take longer to type
- Shifted characters are more error prone

✓ Do	✗ Don't
disable ipsec	Disable IPsec
enable dynamic-ip	enable dynamic_ip
find 'user name'	find "user name"



## 13-14. Make Conversation!

- Give positive feedback
- Ask for confirmation

	✓ Do	✗ Don't
<b>Feedback</b>	<pre>&gt; add user jim99 jim99 has been added to the user database &gt;</pre>	<pre>&gt; add user jim99 &gt;</pre>
<b>Confirmation</b>	<pre>&gt; delete user jim99 Are you sure you want to delete jim99.[y/n]? &gt;</pre>	<pre>&gt; delete user jim99 &gt;</pre>

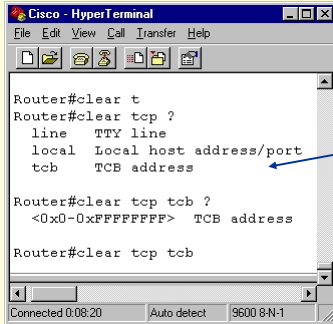


## 15. Use Rich Error Messages

✓ Do	✗ Don't
<pre>&gt; add usr jim99 Did you intend to type: add user jim99 [y/n]?</pre>	<pre>&gt; add usr jim99 Invalid command</pre>
<pre>&gt; edit timeout You forgot to enter the timeout period. Use a value of 1-60 seconds.</pre>	<pre>&gt; edit timeout Parameter invalid or missing</pre>
<pre>&gt; edit timeout 65 The timeout period you entered is out of range. Use a value of 1-60 seconds</pre>	<pre>&gt; edit timeout 65 Parameter invalid or missing</pre>



## 16. Provide Meaningful Help



```
Router#clear t
Router#clear tcp ?
  line TTY line
  local Local host address/port
  tcb TCB address

Router#clear tcp tcb ?
<0x0-0xFFFFFFFF> TCB address

Router#clear tcp tcb
```

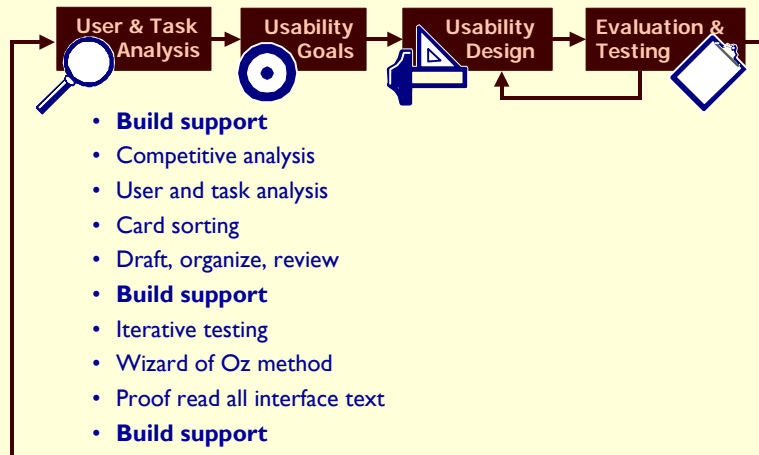
### Make your 68 characters count:

- Don't just restate the command word
- Hint at what's to come

TCB address in hex format



## CLI Design Lifecycle



# Resources & References

## Card Sorting

**Software:** [http://www-3.ibm.com/ibm/easy/eou\\_ext.nsf/Publish/410](http://www-3.ibm.com/ibm/easy/eou_ext.nsf/Publish/410)

**Information:** <http://www.stcsig.org/usability/topics/cardsorting.html>

## Command Language Design Guidelines

Mayhew, D. J. (1992). *Principles and Guidelines in Software User Interface Design*. Prentice Hall: New Jersey.

## References

Barnard, P. J. et al. (1981). Consistency and compatibility in human-computer dialogue. *International Journal of Man-Machine Studies*, 15, 87–134.

Benbasat, I. & Yair, W. (1984). Command abbreviation behavior in human-computer interaction. *Communications of the ACM*, 27(4), 376–383

Bower, G. H., Clark, M. C., Lesgold, A. M., & Winzenz, D. (1969). Hierarchical retrieval schemes in recall of categorized word lists. *Journal of Verbal Learning and Verbal Behavior*, 8, 323–343.



# More References

Carroll, J. M. (1982). Learning, using and designing command paradigms. *Human Learning*, 1(1), 31-62.

Ehrenreich, S. L. (1985). Computer abbreviations: Evidence and synthesis. *Human Factors*, 27(2), 143–156.

Gartner Inc. (2002 a). *LAN Equipment and Routers Worldwide, 2000-2001: Market Trends*

Gartner Inc. (2002 b). *Servers Worldwide Quarterly Statistics, 4Q01*

Gartner Inc. (2002 c). *Worldwide PC Forecast Scenarios Update: 2002-2003*

Grudin, J. & Barnard, P. J. (1985). The cognitive demands of learning and representing command names for text-editing. *Human Factors*, 26(4), 407–422.

Kraut, R. E., Hanson S. J. & Farber J. M. (1983). Command use and interface design. *Proceedings, CHI '83*, 120–124.

Ledgard, H. F. et al. (1980). The natural language of interactive systems. *Communications of the ACM*, 23, 556–563.

Miller, G. A. (1956). The magical number seven, plus or minus two: Some limits on our capacity for processing information. *Psychological Review*, 63, 81-97.

Nobel, P. A. & Shiffrin R. M. (2001). Retrieval processes in recognition and cued recall. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 27(2), 384-413.

Schweickert, R. & Boruff, B. (1986). Short-term memory capacity: Magic number or magic spell? *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 12, 419-425.

