Predictive models: GOMS, KLM, Fitts' Law

Slides based on those by Paul Cairns, York (http://www-users.cs.york.ac.uk/~pcairns/) + ID3 book slides + slides from: courses.ischool.berkeley.edu/i213/s08/lectures/i213-14.**ppt**

Predictive models

- Provide a way of evaluating products or designs without directly involving users.
- Less expensive than user testing.
- Usefulness limited to systems with predictable tasks - e.g., telephone answering systems, mobiles, cell phones, etc.
- Based on expert error-free behavior.

GOMS

- Goals – what the user wants to achieve eg. find a website.
- Operators - the cognitive processes & physical actions needed to attain goals, eg. decide which search engine to use.
- Methods - the procedures to accomplish the goals, eg. drag mouse over field, type in keywords, press the go button.
- Selection rules - decide which method to select when there is more than one.

Keystroke level model

- GOMS has also been developed to provide a quantitative model - the keystroke level model.
- The keystroke model allows predictions to be made about how long it takes an expert user to perform a task.

Response times for keystroke level operators (Card et al., 1983)

Operator	Description	Time (sec)
K	Pressing a single key or button	
	Average skilled typist (55 wpm)	0.22
	Average non-skilled typist (40 wpm)	0.28
	Pressing shift or control key	0.08
	Typist unfamiliar with the keyboard	1.20
P	Pointing with a mouse or other device on a display to select an object. This value is derived from Fitts' Law which is discussed below.	0.40
P1	Clicking the mouse or similar device	0.20
H	Bring 'home' hands on the keyboard or other device	0.40
M	Mentally prepare/respond	1.35
R(t)	The response time is counted only if it causes the user to wait.	t

Summing together

$$T_{\text{execute}} = T_{\text{K}} + T_{\text{P}} + T_{\text{H}} + T_{\text{D}} + T_{\text{M}} + T_{\text{R}}$$

Using KLM to calculate time to change gaze
(Holleis et al., 2007)

Had to add new operators (e.g., Macro Attention shift)

Fitts' Law (Fitts, 1954)

- Fitts' Law predicts that the time to point at an object using a device is a function of the distance from the target object & the object's size.
- The further away & the smaller the object, the longer the time to locate it & point to it.
- Fitts' Law is useful for evaluating systems for which the time to locate an object is important, e.g., a cell phone,
  a handheld devices.

Fitts' Law

Models movement time for selection

Movement time for a rehearsed task

- Increases with distance to target (d)
- Decreases with width of target (s)
- Depends only on relative precision (d/s), assuming target is within arms reach

First demonstrated for tapping with finger (Fitts 1954), later extrapolated to mouse and other input devices

Adapted from Hearst, Newstette

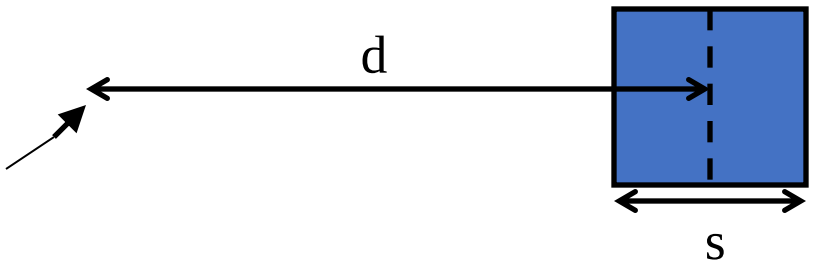
Fitts' Law Equation

$T_{msec} = a + b \log_2 (d/s + 1)$

a, b = empirically-derived constants

d = distance, s = width of target

ID (Index of Difficulty) = $\log_2 (d/s + 1)$



Adapted from Robert Miller

A Fitts’ law demo

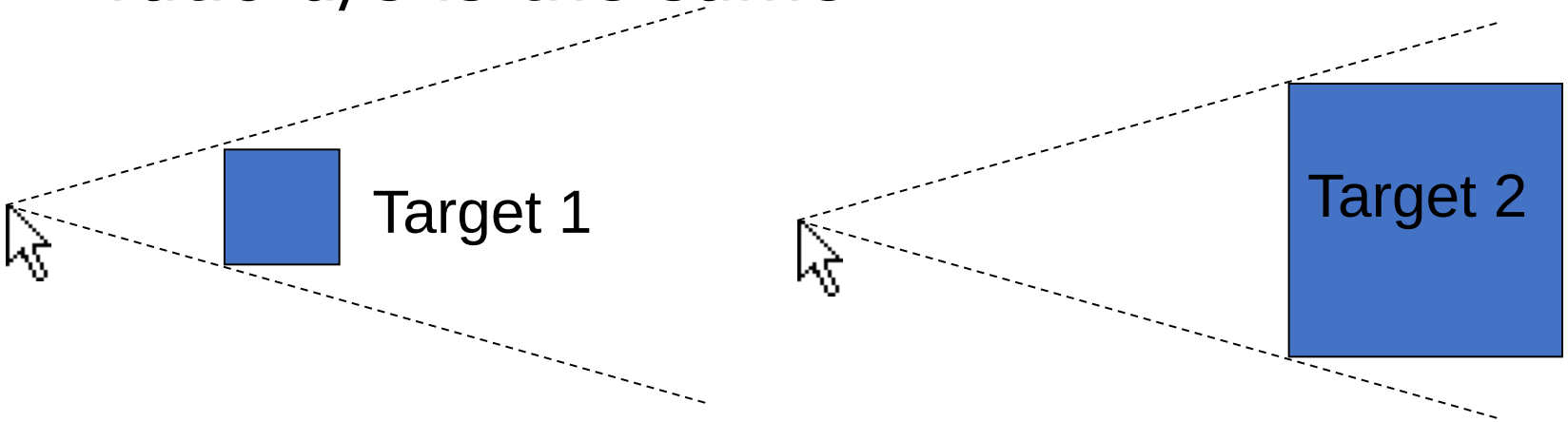
Interactive Fitts' Law talk

Fitts' Law Intuition

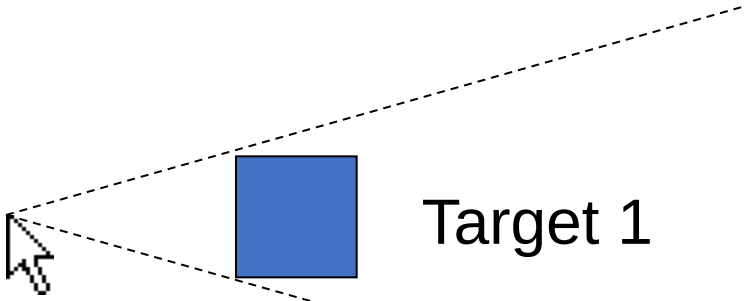
Time depends on *relative precision* (d/s)

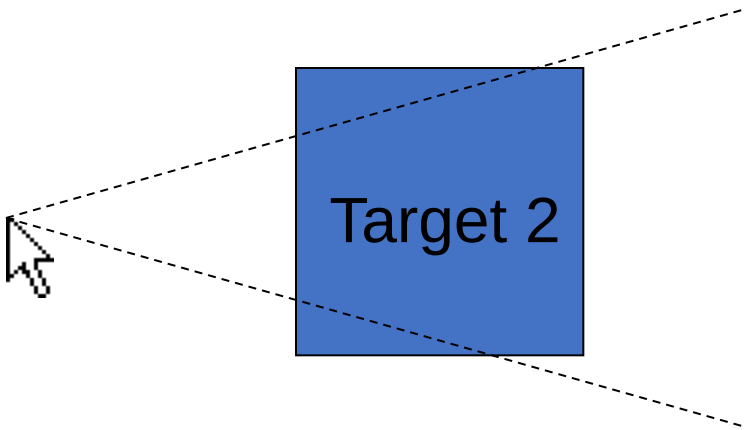
Time is not limited by motor activity of moving your arm / hand, but rather by the cognitive activity of keeping on track

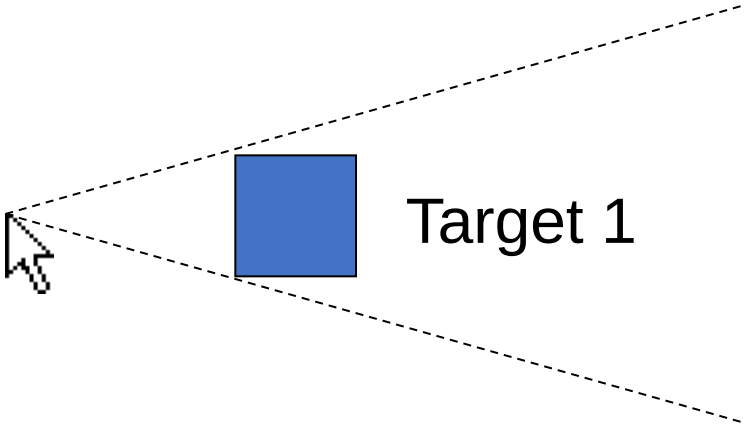
Below, time will be the same because the ratio d/s is the same

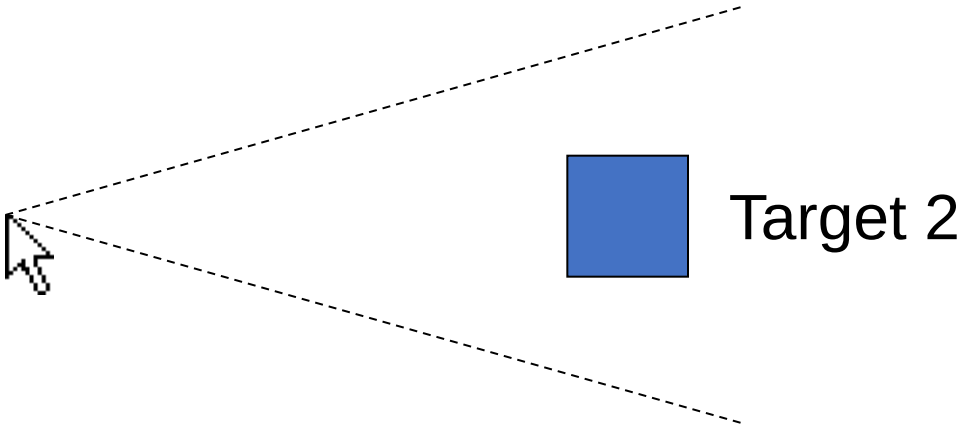


Fitts' Law Examples









Adapted from Hearst, Irani

Determining a,b Constants

Conduct experiments varying d,s but keeping everything else the same

Measure execution time, error rate, accuracy

Exclude erroneous data

Perform linear regression

Exercise…Fitts' Law

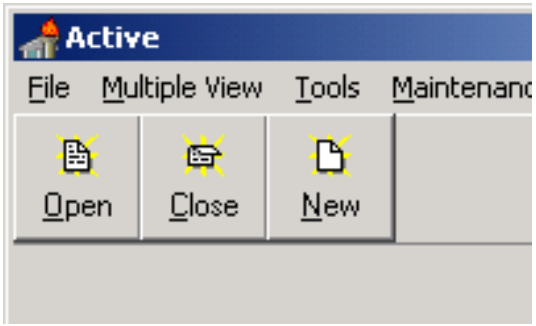
Visit Tog's website and do Tog's quiz, designed to give you fitts!

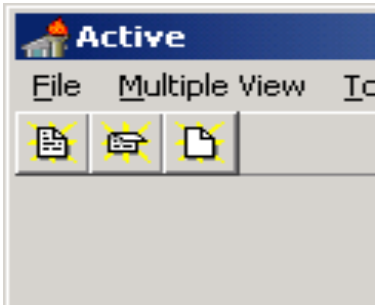
http://www.asktog.com/columns/022DesignedToGiveFitts.html

Fitts in Practice

Microsoft Toolbars allow you to either keep or remove the labels under Toolbar buttons

According to Fitts' Law, which is more efficient?





Source: http://www.asktog.com/columns/022DesignedToGiveFitts.html

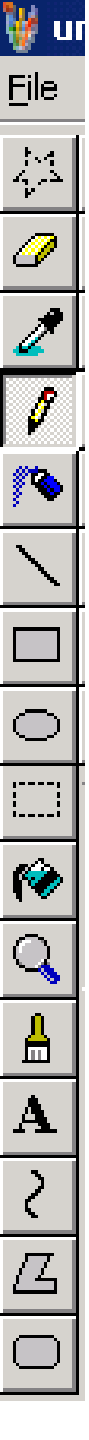
Adapted from Hearst,

Fitts in Practice

You have a toolbar with 16 icons, each with dimensions of 16x16

Without moving the array from the left edge of the screen, or changing the size of the icons, how can you make this more efficient?

Adapted from Hearst, Irani



Fitts in Practice

Answer: Line up all 16 icons on the left hand edge of the screen

Make sure that each button can be activated up the last pixel on the left hand edge

Why? Because you cannot move your mouse off of the screen, the effective width s is infinite

Adapted from Hearst, Irani

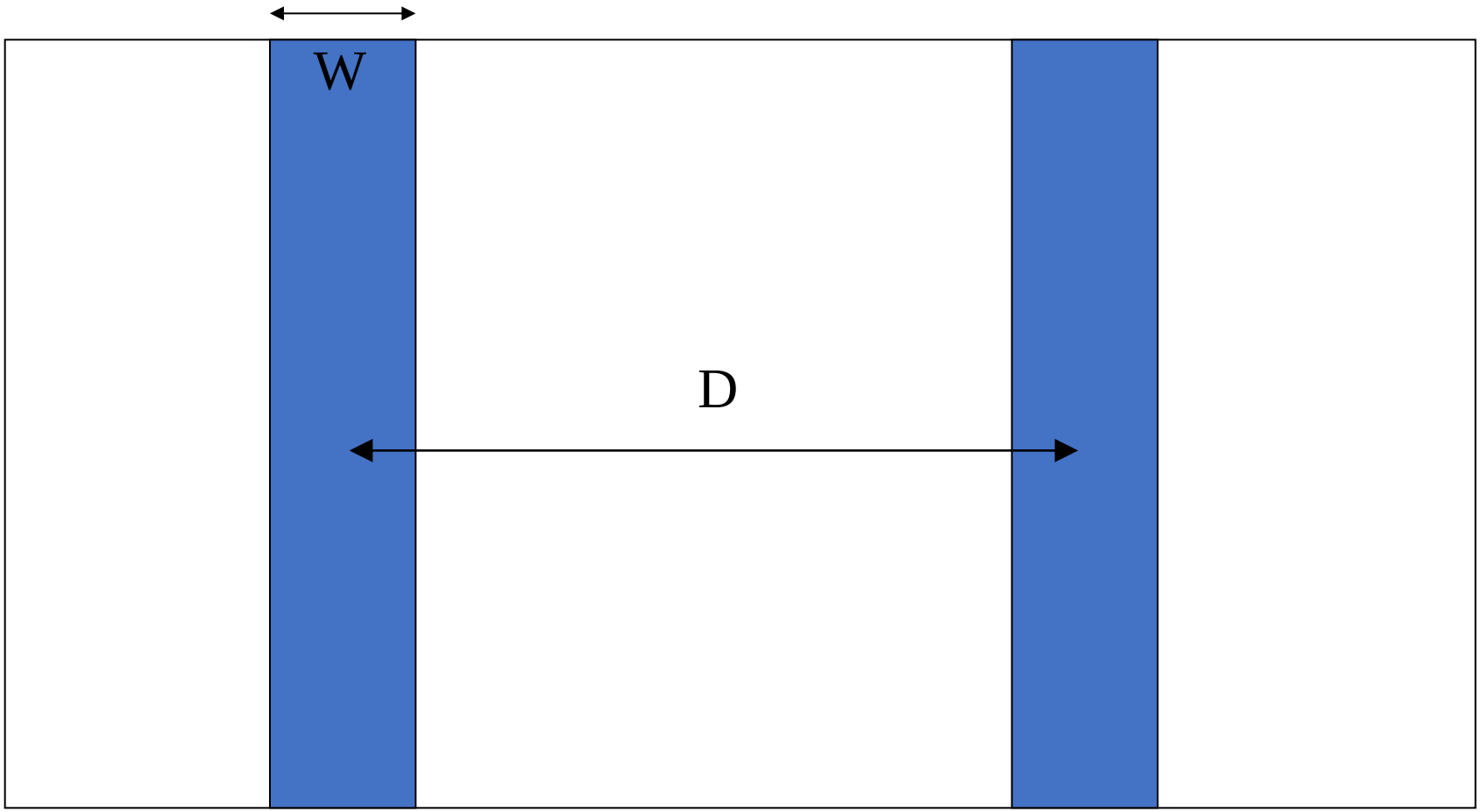
Impact in HCI

- Reduce ID
  - Bigger icons, more space
- Compare IP
  - “Capacity” of input devices
- Put things in edges and corners

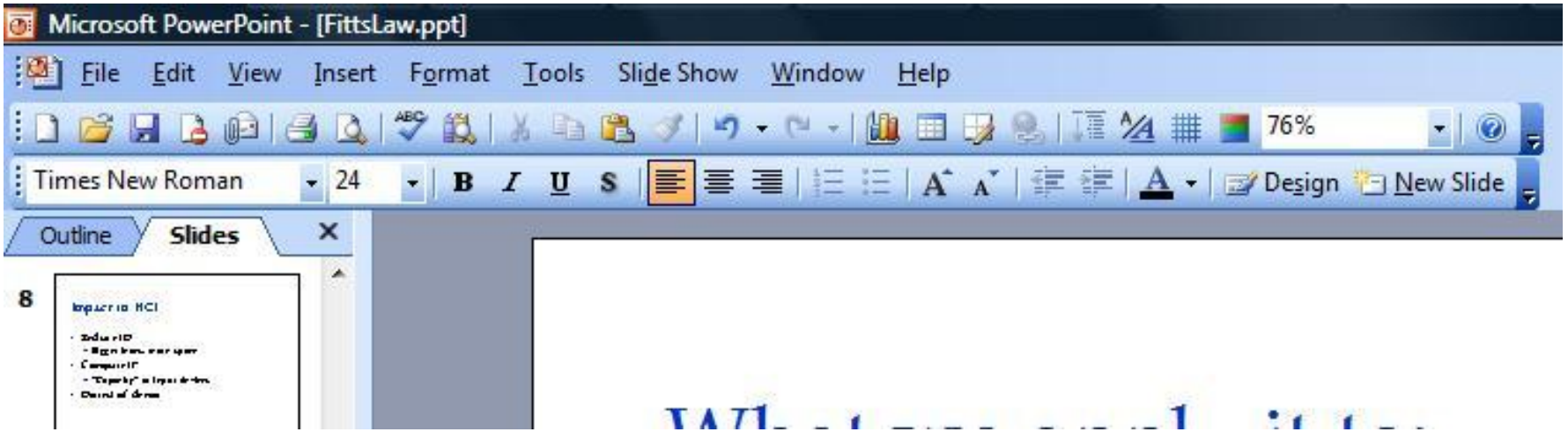
Deconstructing Fitts

- Ecological validity
- Construct validity

What Fitts did:



What we apply it to:



Correcting for W

- W’ – actual cross-section
- Smaller of W and H
- Area, W x H
- Sum, W + H
- Stick with W
- Which is best?

Toolbars

- Annoying or useful?
- 

Novel interactions

- Artificially increasing W
  - “Sticky” buttons
  - Bubbles
- Changing select
  - Goal-crossing

Advanced Fitts' Law

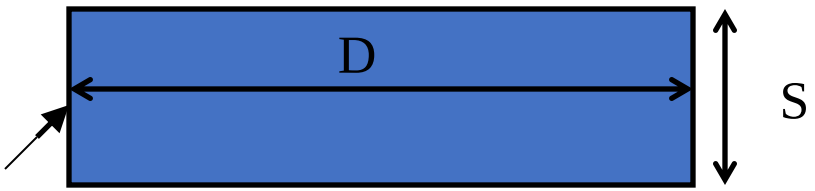
- Fitts' law as a model
- Steering law
  - Games
  - Menu navigation
  - VE/VR?

Steering Law

Applies same principles to *steering* through a tunnel (Accot, Zhai 1997)

Must keep the pointer within the boundaries throughout, not only at the target

In KLM, Fitts' Law used for pointing, Steering Law used for drawing



Steering Law Equation

$T_{msec} = a + b\ (d/s)$

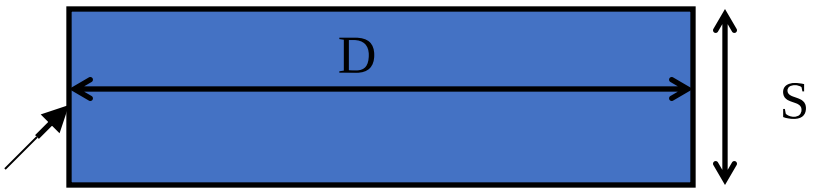
a, b = empirically-derived constants

d = distance, s = width of tunnel

ID (Index of Difficulty) = (d/s)

Index of Difficulty now *linear*, not logarithmic

(i.e. steering is more difficult then pointing)



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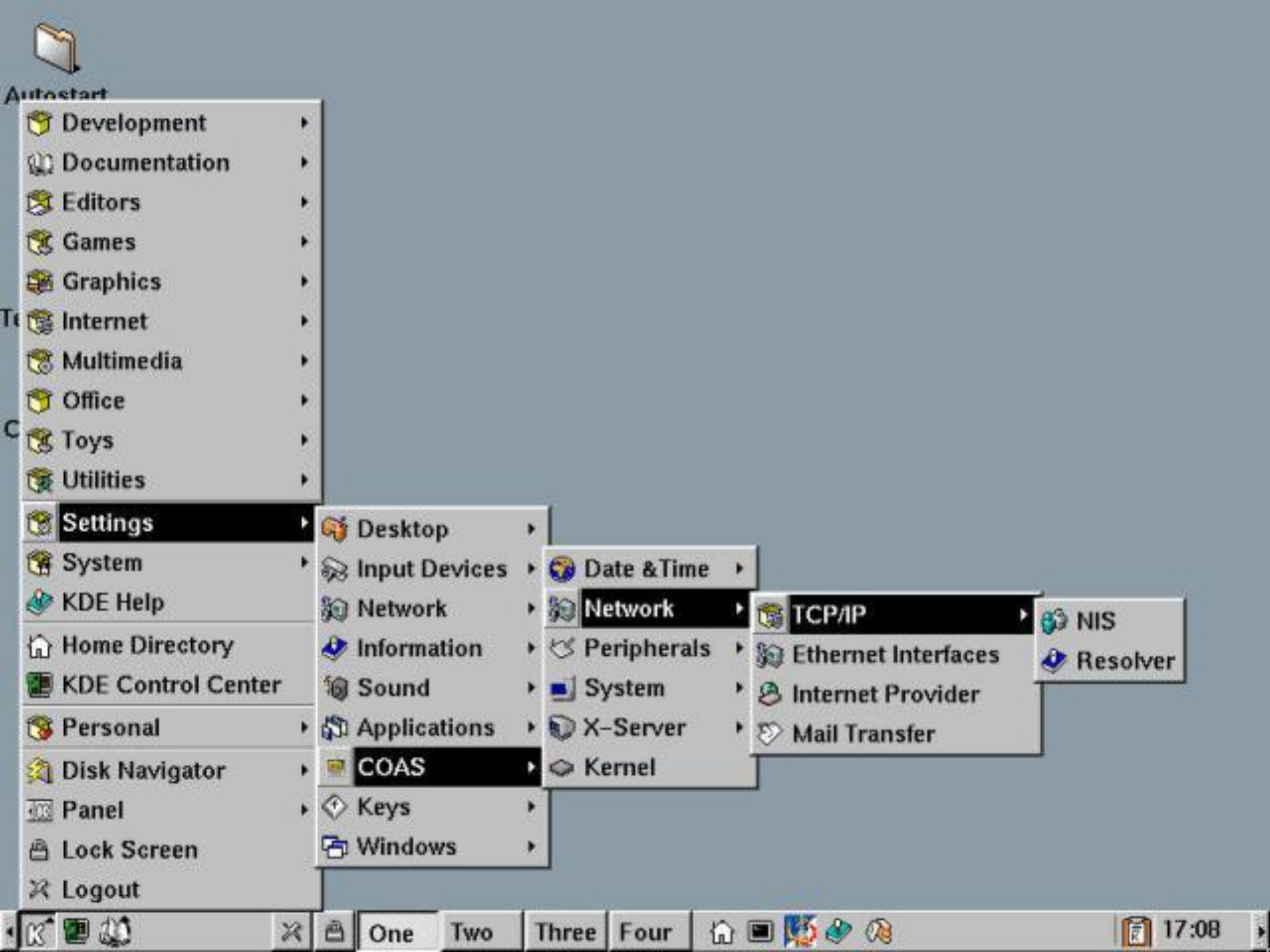
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Three
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