Notes on Contemporary Table Recognition

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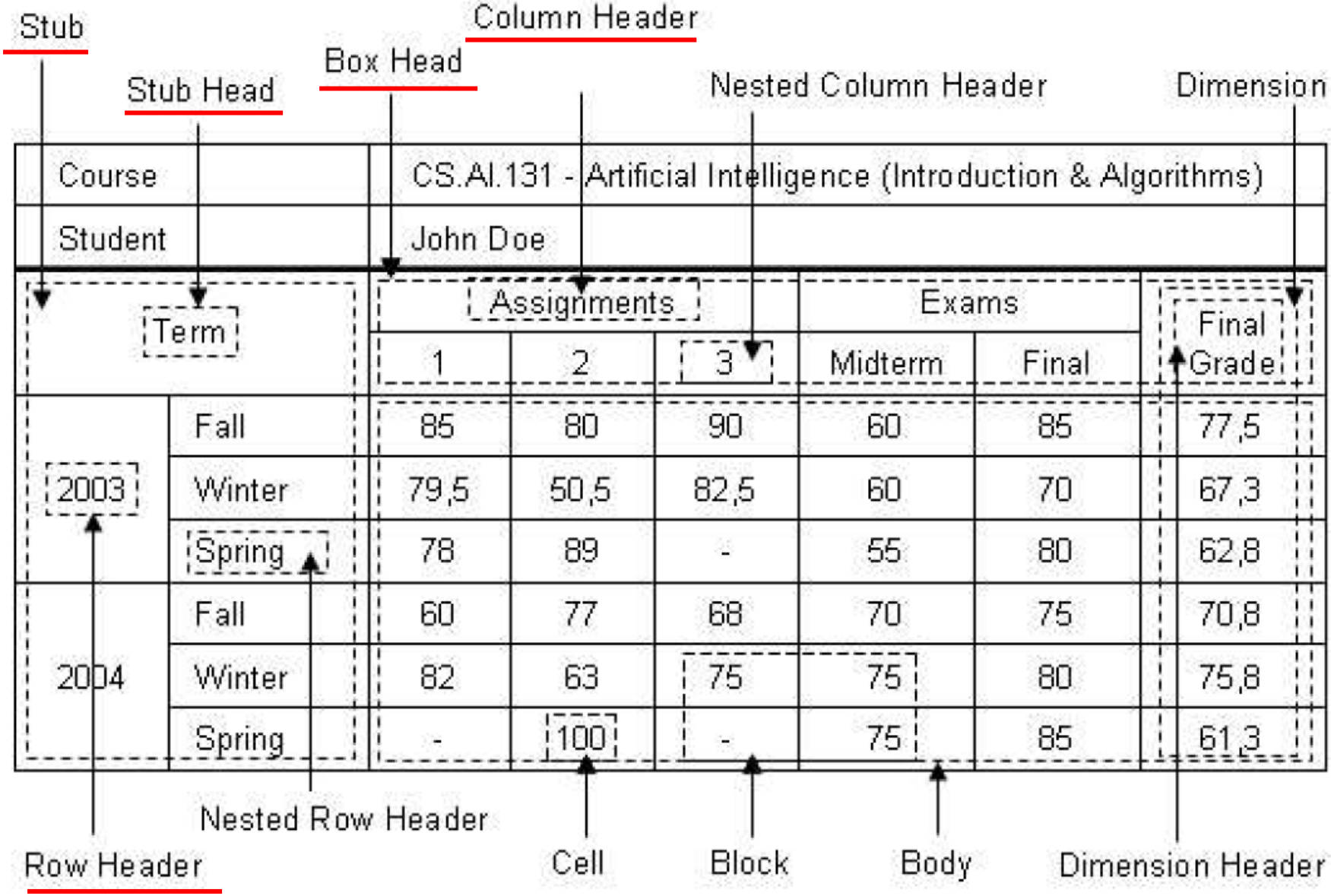
and David W. Embley (BYU), and Daniel Lopresti (Lehigh University) and NSF # 0414854

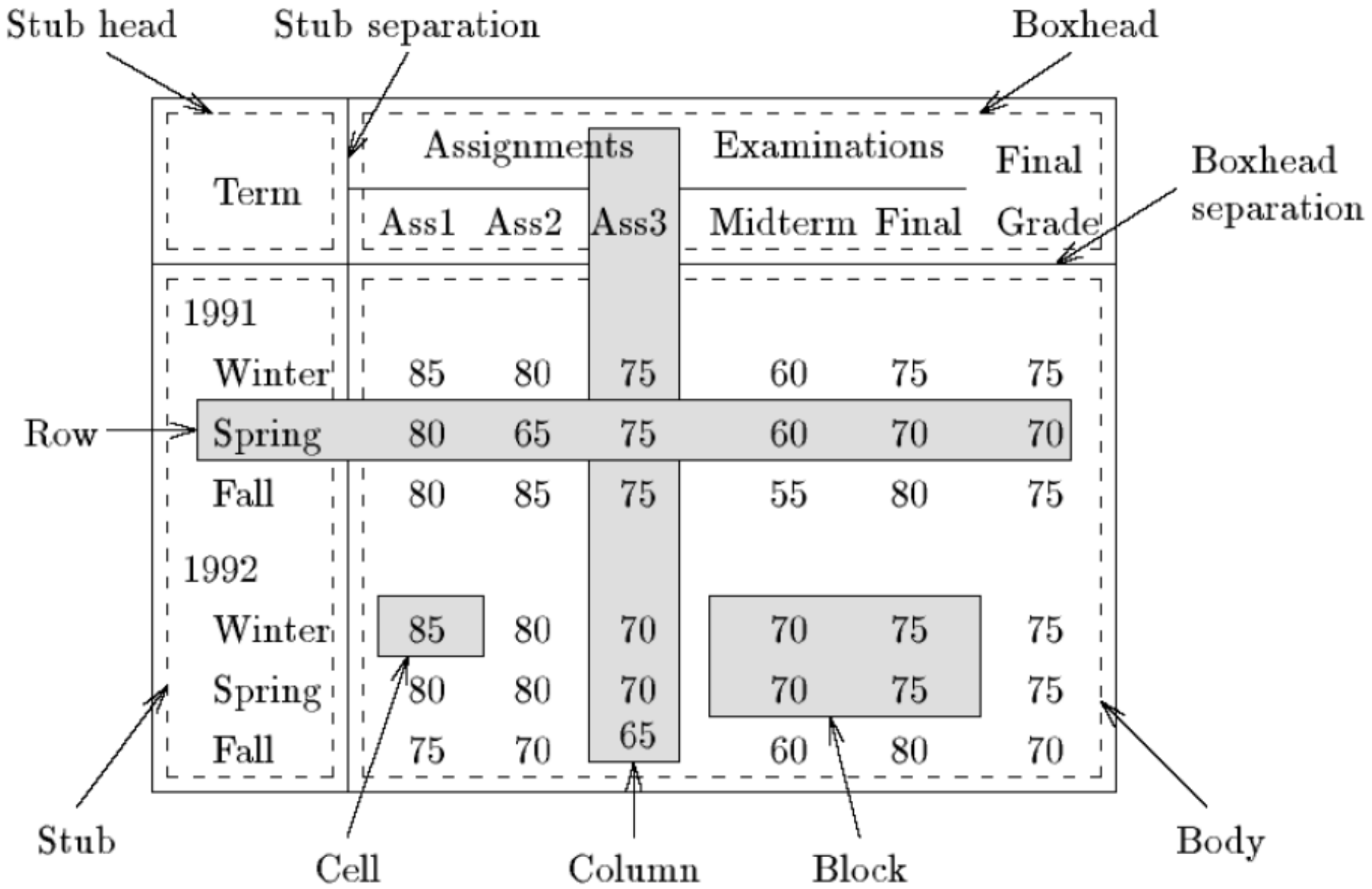
and my past and current students, and all the folks on whose work I have freely.

Traditional Terminology



[Pivk et al]

Traditional Terminology (2)



Levels of Table Recognition

Start: Print, ASCII, HTML, PDF, EXCEL, …

- Detection, isolation, extraction
- Structural analysis (recover 2-D array structure)
- Canonicalization (distribute headers)
- Transcription (recover text)
- Interpretation (Wang Notation: layout-independent representation)
- Understanding (?)

End: editable/reconfigurable/reusable table, DB, IR, DM, SWeb

Detection, isolation, extraction

5. Evaluation of WNT

Every attempt by every subject was recorded in detail during evaluation. An example of the complete log for one attempt appears in Appendix E. The log recorded times and button clicks made by the user, specifying whether the button click was to undo a mistake or not. A subject's interaction with WNT can be re-created with the logs. Appendix G shows summaries of times for every table.

An example summary table for T09 is shown in Table 5. All values (time in seconds) are averages over subjects. *# of attempts* is the average number of attempts made by all subjects on a table. *Time for Pre-Processing* (computer time) is the time taken to display the original HTML table, convert the ASCII file to a Matlab array, and display a corresponding GUI to the subject. *Time to Construct Categories* (subject time) is the time taken by subjects to think about and click the cells designating categories. This time indicates the confusion factor (Section 0) of a table; subjects spend more time constructing categories when a table is confusing.

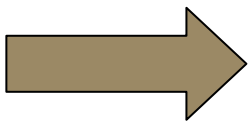
Time for Category Correction (subject time) is the time subjects took to correct all categories in the table using the error-correction GUI. This time is higher for confusing and badly-formed tables and lower when subjects have seen similar tables before. *Time for Final Processing* (computer time) is the time taken to perform final category processing, generate category notation, generate delta notation, and generate the XML representation. *Total Time* is the addition of all time and *% Subject Time* is the percent of total time that is subject time.

Table 5: Distribution of Processing Time for T09, Average Over All Subjects

	AVERAGE	STD. DEVIATION
# of attempts	1.67	0.65
Time for Pre-Processing	0.52	0.10
Time to Construct Categories	80.68	67.63
Time for Category Correction	103.21	126.45
Time for Final Processing	0.42	0.19
Total Time	184.81	192.11
Percent Table is Completed	77.78	35.06
% Subject Time	0.99	0.01

Wang notation was generated in 82.75% of all attempts and was generated *correctly* in 57.25% of all attempts (Table 6). Figure 45 shows the results of the evaluation by

50



	AVERAGE	STD. DEVIATION
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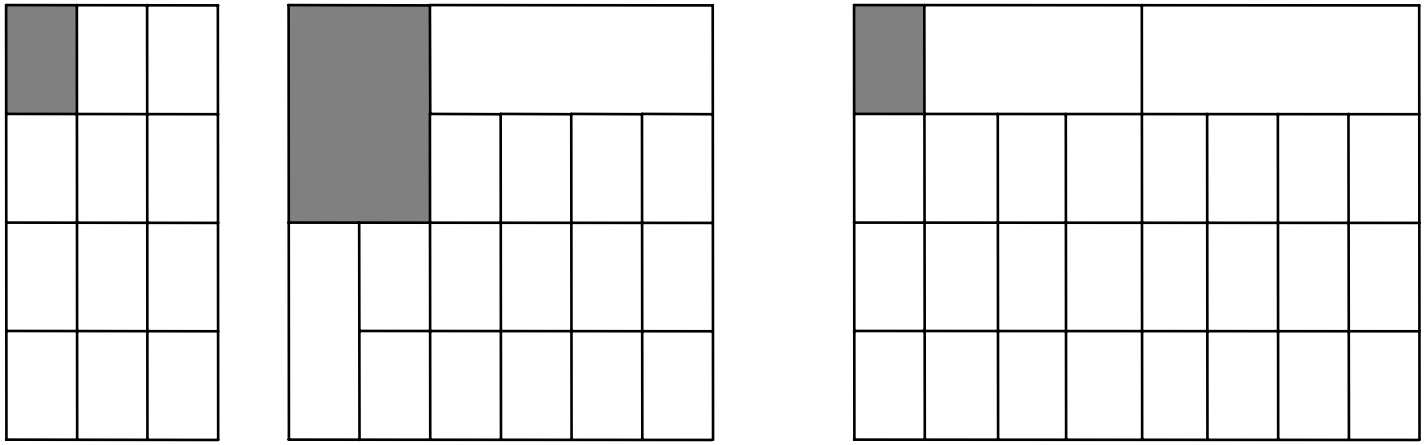
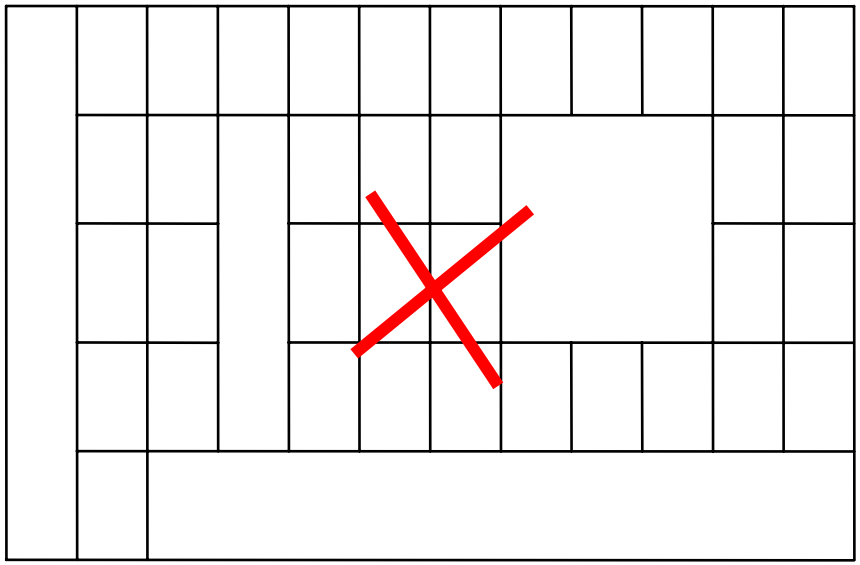
Total Time	184.81	192.11
Percent Table is Completed	77.78	35.06
% Subject Time	0.99	0.01

Array Models for Structural Analysis





Cells are larger left and top

“Canonicalization”

Year	Term	Mark					
		Assignments			Examinations		Grade
		Ass1	Ass2	Ass3	Midterm	Final	
1991	Winter	85	80	75	60	75	75
	Spring	80	65	75	60	70	70
	Fall	80	85	75	55	80	75
1992	Winter	85	80	70	70	75	75
	Spring	80	80	70	70	75	75
	Fall	75	70	65	60	80	70

?	?	Mark	Mark	Mark	Mark	Mark	Mark
?	?	Ass’t	Ass’t	Ass’t	Exams	Exams	Grade
?	?	Ass 1	Ass 2	Ass 3	Midterm	Final	Grade
1991	Winter	85	80	75	60	75	75
1991	Spring	80	65	75	60	70	70
1991	Fall	80	85	75	55	80	75
1992	Winter	85	80	70	70	75	75
1992	Spring	80	80	70	70	75	75
1992	Fall	75	70	65	60	80	70

Asymmetry

AGE	MALE		FEMALE	
	WEIGHT	HEIGHT	WEIGHT	HEIGHT
5				
10				
15				

		MALE		FEMALE	
		WEIGHT	HEIGHT	WEIGHT	HEIGHT
AGE	5				
	10				
	15				

Example of low-level analysis

Table I

fleck	**gonsity (ld/gg)**	**hepth (gd)**
burlam	1.2	120
falder	2.3	230
multon	2.5	350

Structural Analysis

XXXXX	XXXXXXX XXXX	XXXXX XXX
XXXXX	XXX	XXX
XXXXX	XXX	XXX
XXXXX	XXX	XXX

Table Transcription

fleck	gonsity (ld/gg)	hepth (gd)
burlam	1.2	120
falder	2.3	230
multon	2.5	350

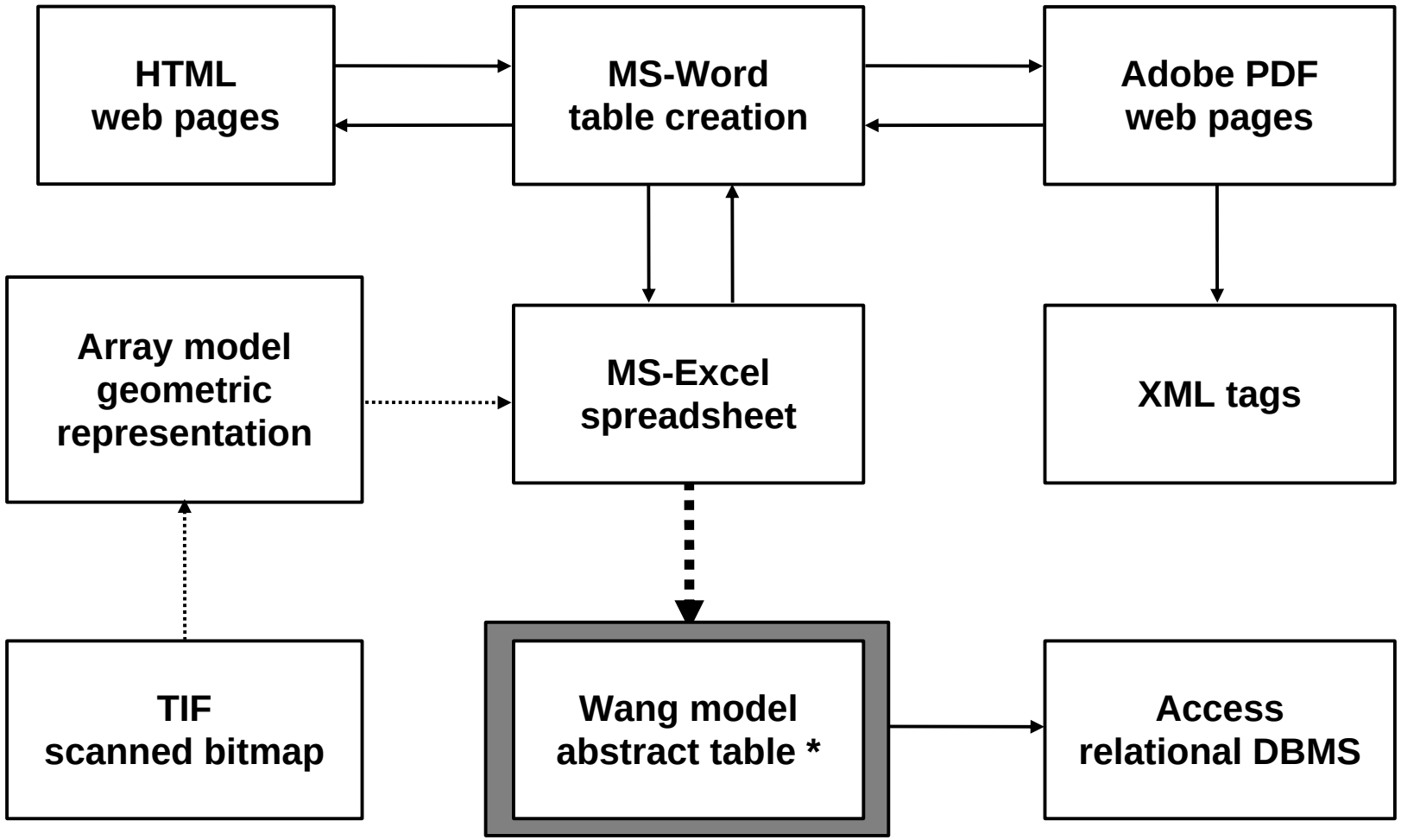
Another relevant table

Table II

goldam	1.2 ld/gg	120 gd
falder	2.3 ld/gg	230 gd
elmer	2.5 ld/gg	350 gd

Table transcription is not sufficient for combining information from Table I and Table II. But it can often be accomplished with current commercial software.

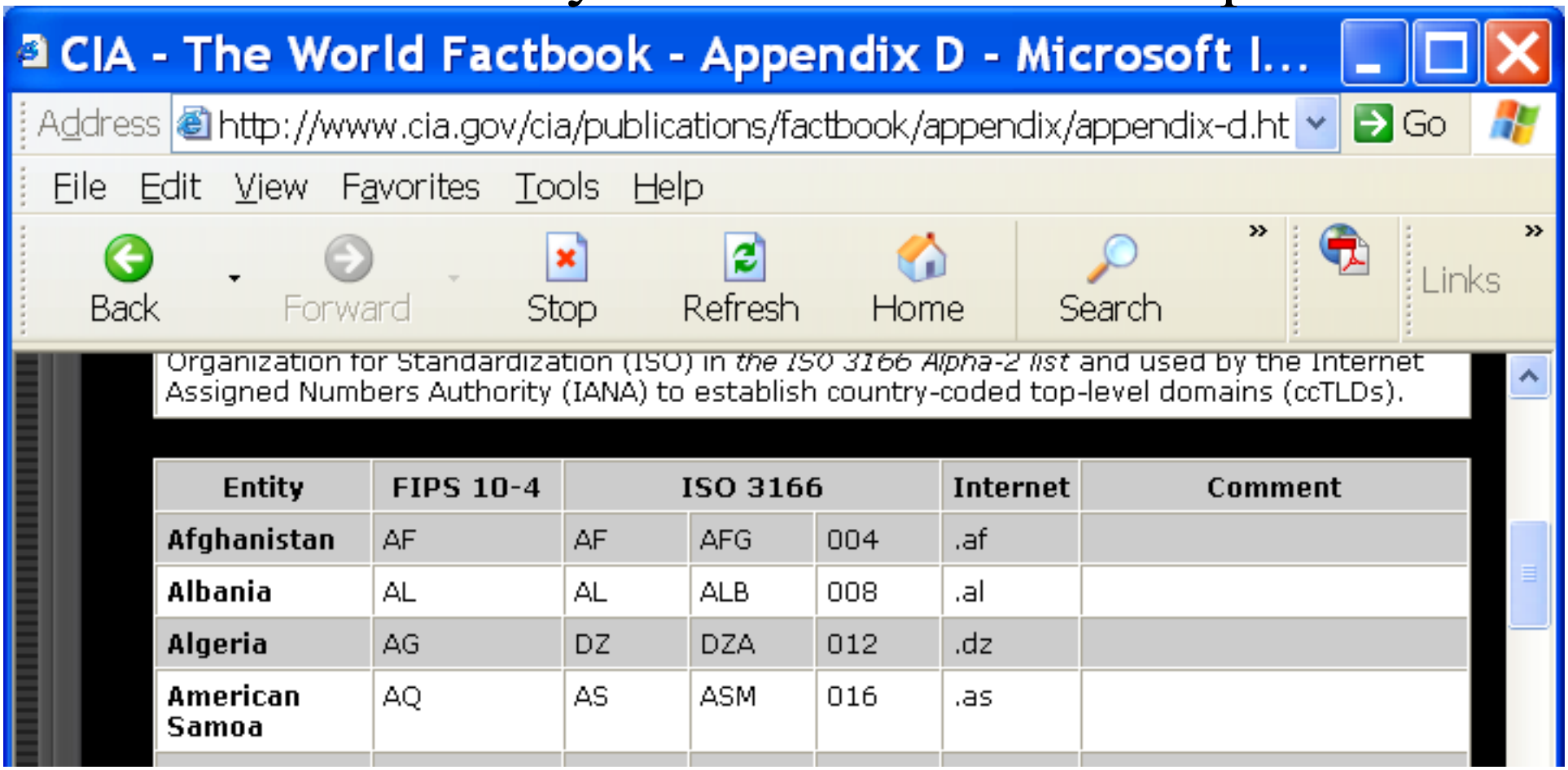
Existing Table Conversion Software



* *Tabular abstraction, editing, and formatting*, Xinxin Wang, PhD thesis, University of Waterloo, 1996.

Existing Table Conversion Software

Table as rendered by Microsoft Internet Explorer 6.0:



Entity	FIPS 10-4	ISO 3166			Internet	Comment
Afghanistan	AF	AF	AFG	004	.af	
Albania	AL	AL	ALB	008	.al	
Algeria	AG	DZ	DZA	012	.dz	
American Samoa	AQ	AS	ASM	016	.as	

Existing Table Conversion Software

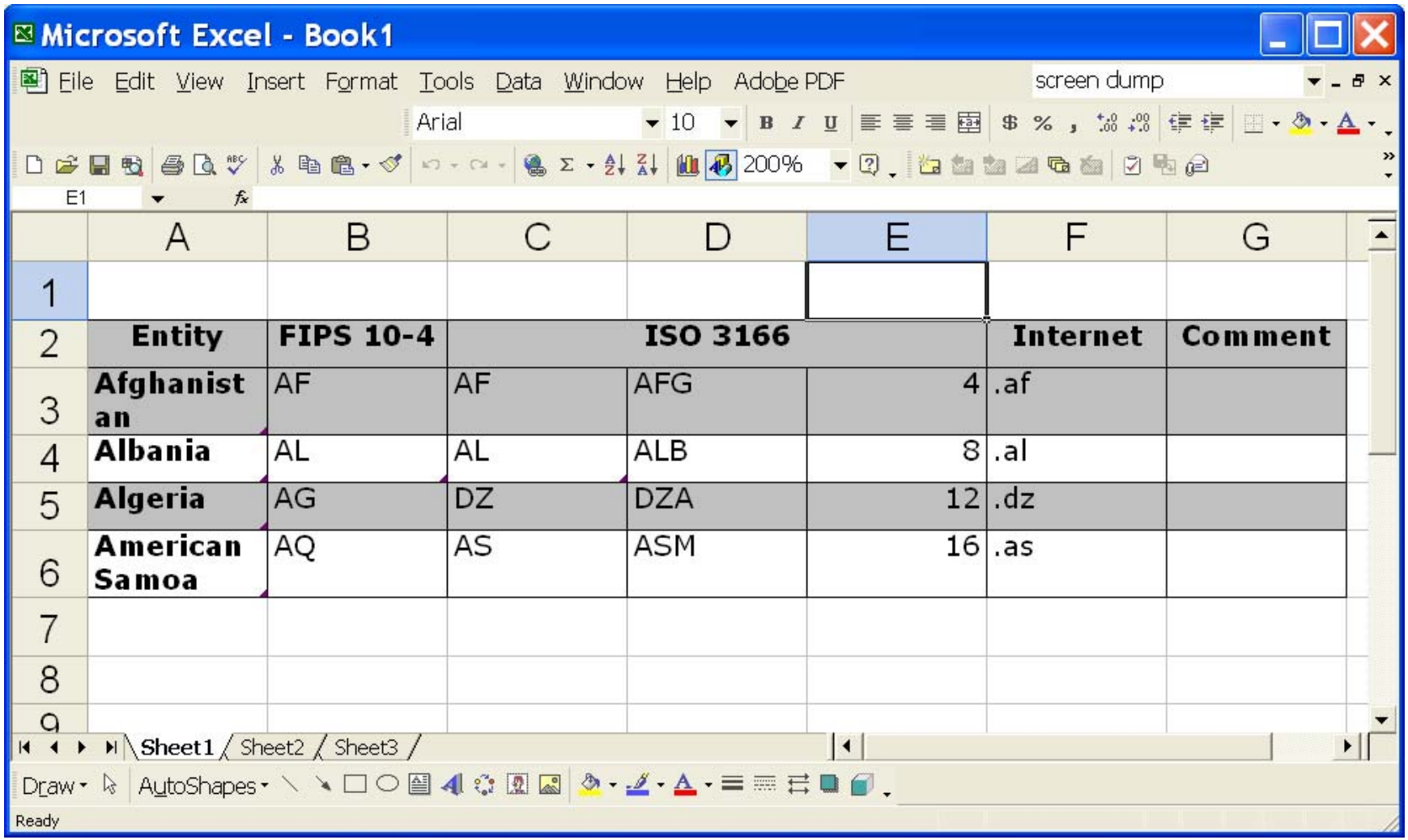
Table copied into Microsoft Word 10.2:

Entity	FIPS 10- 4	ISO 3166			Internet	Comment
Afghanistan	AF	AF	AFG	004	.af	
Albania	AL	AL	ALB	008	.al	
Algeria	AG	DZ	DZA	012	.dz	
American Samoa	AQ	AS	ASM	016	.as	

Not as an image or graphics!

Existing Table Conversion Software

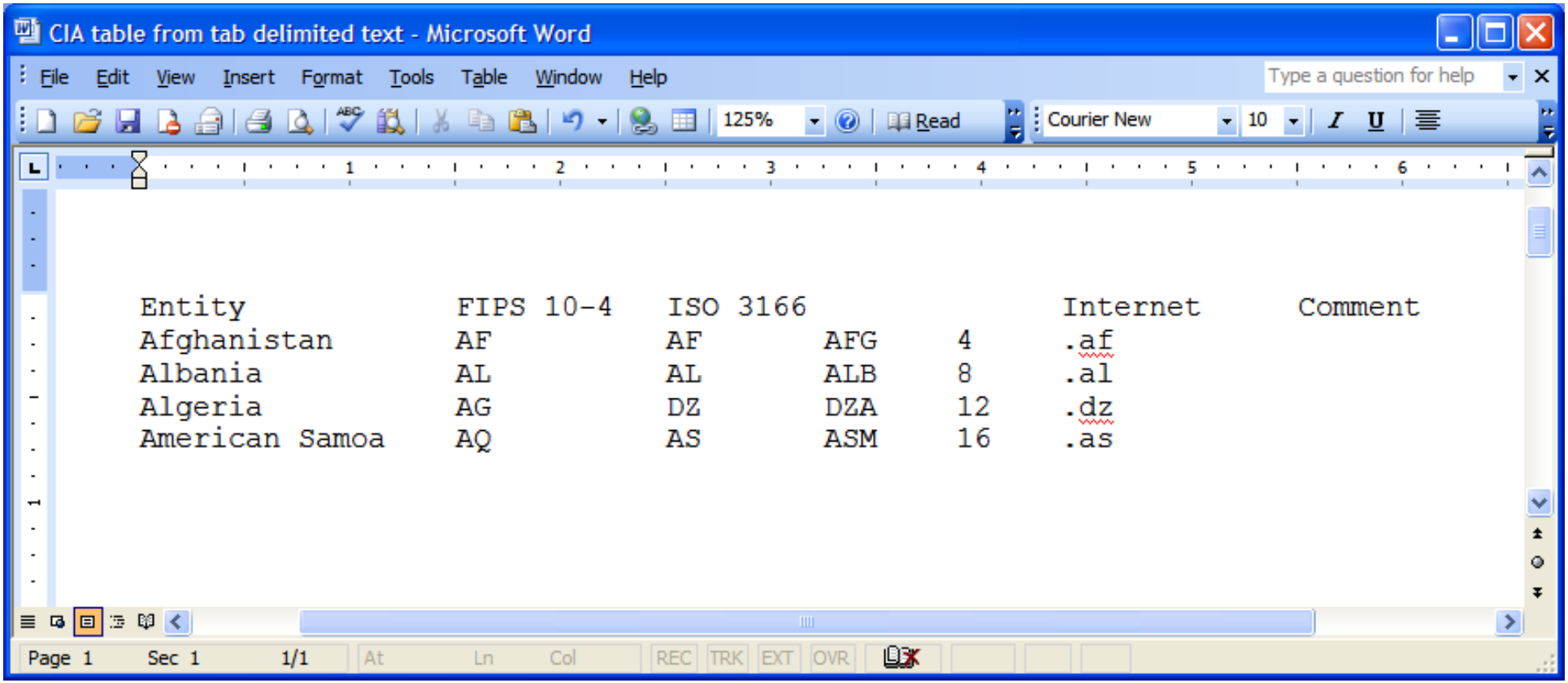
Table copied from Microsoft Word into Excel 10.2:



	A	B	C	D	E	F	G
1							
2	**Entity**	**FIPS 10-4**	**ISO 3166**			**Internet**	**Comment**
3	**Afghanistan**	AF	AF	AFG	4	.af	
4	**Albania**	AL	AL	ALB	8	.al	
5	**Algeria**	AG	DZ	DZA	12	.dz	
6	**American Samoa**	AQ	AS	ASM	16	.as	
7							
8							
9							

Existing Table Conversion Software

ASCII version of the table (as rendered by MS Word):



Existing Table Conversion Software

Table rendered from a PDF file:

Table 3. Dissimilarity indexes of labor force projections

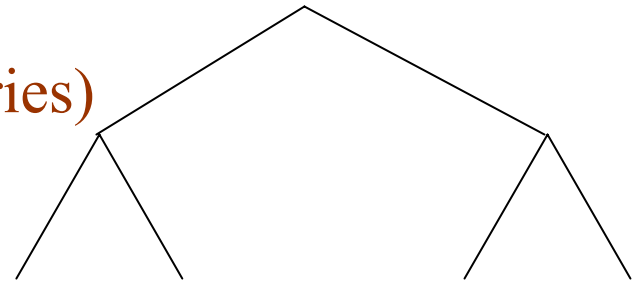
Age	BLS projections	Standards of comparison		
		Actual population and—		Census population estimate and—
		BLS participation rate	1988 participation rate	1988 participation rate
Gender, age	1.83	2.02	2.24	2.32
Men, age	1.63	.91	.62	1.37
Women, age	1.91	2.86	2.4	1.32

Can be saved at .rtf

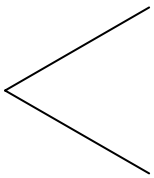
Table Interpretation (row/col header ←→content cell relations)

- Table headers as category trees
- *Dimensionality* (number of categories)
- Tables as *hypercubes*
- Wang Notation

roots?



This is a 2-D table



	INCOME		EXPENSE	
	SERVICES	PRODUCTS	SALARIES	TAXES
2008	8,000,000	12,500,000	4,000,000	1,700,000
2009	8,800,000	14,000,000	4,500,000	1,800,000

Any combination of paths through the category trees must lead to a delta cell;
Each delta cell can be reached through a combination of catergory paths.

Table Interpretation

(stub)		virtual column header ("characteristic")	
		gonsity (ld/gg)	hepth (gd)
fleck	burlam	1.2	120
	falder	2.3	230
	multon	2.5	350

"Layout-invariant" Wang Notation

Categories

$$C = (\text{fleck}, \{(\text{bulram}, \phi), (\text{falder}, \phi), (\text{multon}, \phi)\}),$$
$$(\text{characteristic}, \{(\text{gonsity}, \phi), (\text{hepth}, \phi)\}).$$

Header cell mappings

$$\delta = (\{\text{fleck.burlam}, \text{characteristic.gonsity}\}) \rightarrow 1.2$$
$$(\{\text{fleck.falder}, \text{characteristic.gonsity}\}) \rightarrow 2.3$$
$$\ldots$$
$$(\{\text{fleck.multon}, \text{characteristic.hepth}\}) \rightarrow 350$$

Essentially a set of category trees with common leaf cells – requires modification for table interpretation.

Table III

		fleck		
		burlam	falder	multon
virtual row header	gonsity (ld/cg)	1.2	2.3	2.5
	hepth (ld/cg)	120	230	350

Same Wang Notation as Table I.

Table I

fleck	gonsity (ld/cg)	hepth (cd)
burlam	1.2	120
falder	2.3	230
multon	2.5	350

Well-Formed Tables (WFT)

D1	C1	B1	A1	delta
D1	C1	B1	A2	delta
D1	C1	B2	A1	delta
D1	C1	B2	A2	delta
D1	C1	B3	A1	delta
D1	C1	B3	A2	delta
D1	C2	B1	A1	delta
D1	C2	B1	A2	delta
D1	C2	B2	A1	delta
D1	C2	B2	A2	delta
D1	C2	B3	A1	delta
D1	C2	B3	A2	delta
D1	C3	B1	A1	delta
D1	C3	B1	A2	delta
D1	C3	B2	A1	delta
D1	C3	B2	A2	delta
D1	C3	B3	A1	delta
D1	C3	B3	A2	delta
D1	C4	B1	A1	delta
D1	C4	B1	A2	delta
D1	C4	B2	A1	delta
D1	C4	B2	A2	delta
D1	C4	B3	A1	delta
D1	C4	B3	A2	delta

every row unique

	C1	B1	A1
	C1	B1	A1
	C1	B1	A1
	C1	B1	A1
	C1	B1	A1
	C1	B1	A1
	C2	B1	A1
	C2	B1	A1
	C2	B2	A1
	C2	B2	A1
	C2	B2	A1
	C2	B2	A1
	C3	B2	A2
	C3	B2	A2
	C3	B2	A2
	C3	B2	A2
	C3	B3	A2
	C3	B3	A2
	C4	B3	A2
	C4	B3	A2
	C4	B3	A2
	C4	B3	A2
	C4	B3	A2
	C4	B3	A2

#items	4	3	2
# repetitions	6	8	12
# list rows	24	24	24

D1	C1	B1	A1
D1	C1	B1	A2
D1	C1	B2	A1
D1	C1	B2	A2
D1	C1	B3	A1
D1	C1	|B4|	A2
D1	C2	B1	A1
D1	C2	B1	A2
D1	C2	B2	A1
D1	C2	B2	A2
D1	C2	B3	A1
D1	C2	B3	A2
D1	C3	B1	A1
D1	C3	B1	A2
D1	C3	B2	A1
D1	C3	B2	A2
D1	C3	B3	A1
D1	C3	B3	A2
D1	C4	B1	A1
D1	C4	B1	A2
D1	C4	B2	A1
D1	C4	B2	A2
D1	C4	B3	A1
D1	C4	B3	A2

every row unique

row headers and column analyzed separately

6-D table

Table 5. Average temperatures, 1900/2000, degrees centigrade

	HEMISPHERE		S	S	S	S	N	N	N	N
	LATITUDE		10°	10°	20°	20°	10°	10°	20°	20°
	WATER/LAND		water	land	water	land	water	land	water	land
YEAR	SEASON	TIME								
1900	summer	noon	32	35	37	39	30	33	35	38
1900	summer	midnight	28	32	33	35	26	29	30	35
1900	winter	noon	21	25	28	28	21	24	25	26
1900	winter	midnight	18	22	24	26	17	20	17	22
2000	summer	noon	33	37	37	40	30	33	36	39
2000	summer	midnight	29	32	34	35	26	29	30	35
2000	winter	noon	21	25	27	28	22	23	24	26
2000	winter	midnight	20	22	25	26	18	21	18	22

6-D table (cont'd)

Table 5. Average temperatures, North and South himisphere, degrees centigrade

		LATITUDE WATER/LAND		10° water	10° land	20° water	20° land
HEMI-SPHERE	YEAR	SEASON	TIME				
S	1900	summer	noon	32	35	37	39
S	1900	summer	midnight	28	32	33	35
S	1900	winter	noon	21	25	28	28
S	1900	winter	midnight	18	22	24	26
S	2000	summer	noon	33	37	37	40
S	2000	summer	midnight	29	32	34	35
S	2000	winter	noon	21	25	27	28
S	2000	winter	midnight	20	22	25	26
N	1900	summer	noon	30	33	35	38
N	1900	summer	midnight	26	29	30	35
N	1900	winter	noon	21	24	25	26
N	1900	winter	midnight	17	20	17	22
N	2000	summer	noon	30	33	36	39
N	2000	summer	midnight	26	29	30	35
N	2000	winter	noon	22	23	24	26
N	2000	winter	midnight	18	21	18	22

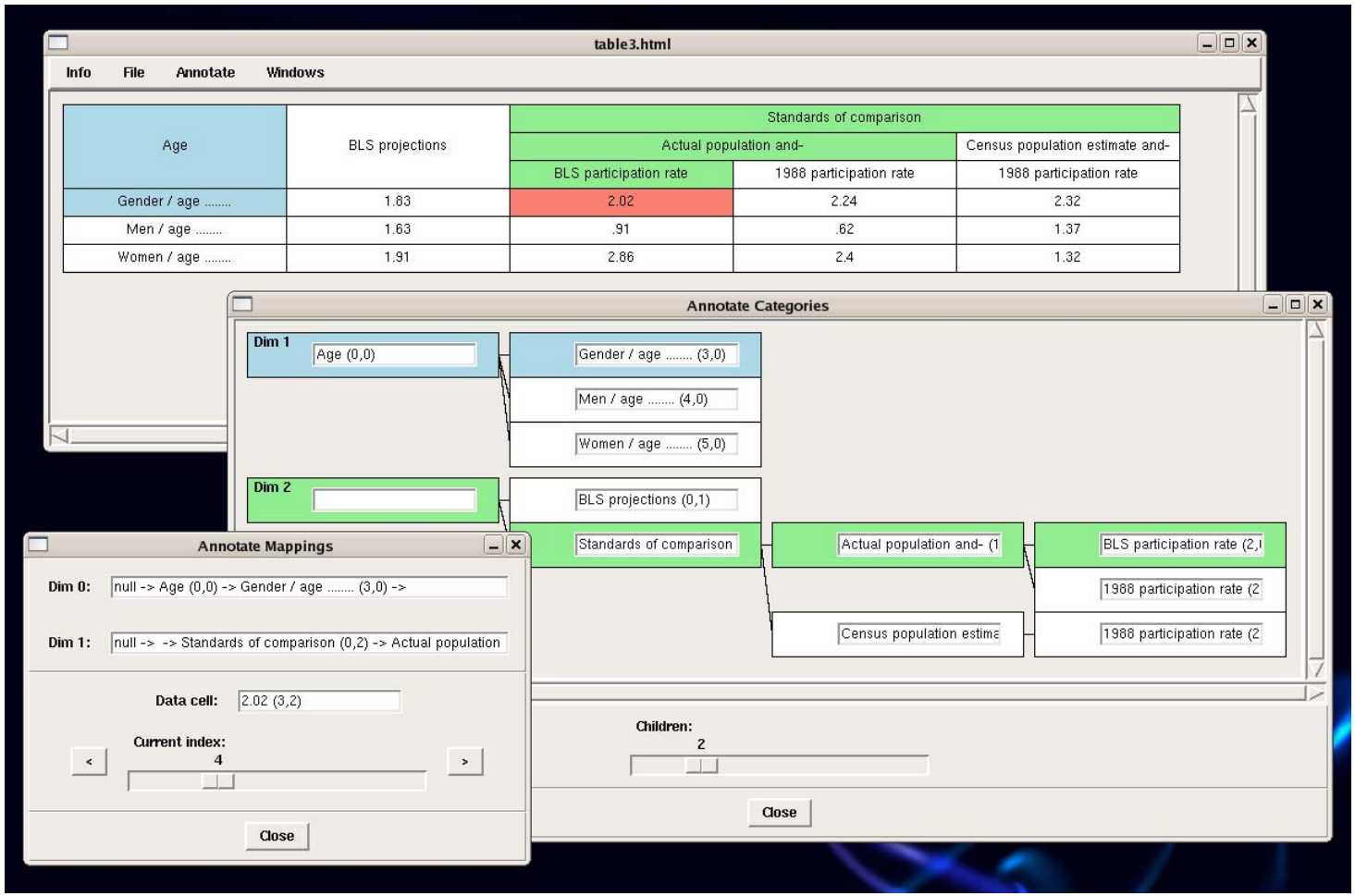
(same data, different emphasis)

On Human Interaction

- Complete automation is still out of reach.
- Some HCI is unavoidable, sooner or later.
- Sooner is better than later.
- Discovering errors later increases negative consequences (and potential for embarrassment).
- Partial automation + interaction is more accurate than machine alone and faster than unaided human.
- *TabbyCat* (for "table categorizer") and *WNT* (Wang Notation Tool) are prototype interactive tools for supporting Wang-style markup.

Table Annotation & Truthing

Snapshot of *TabbyCat* for creating Wang-style table mark-up:



[Lopresti]

Table Annotation & Truthing

TabbyCat:

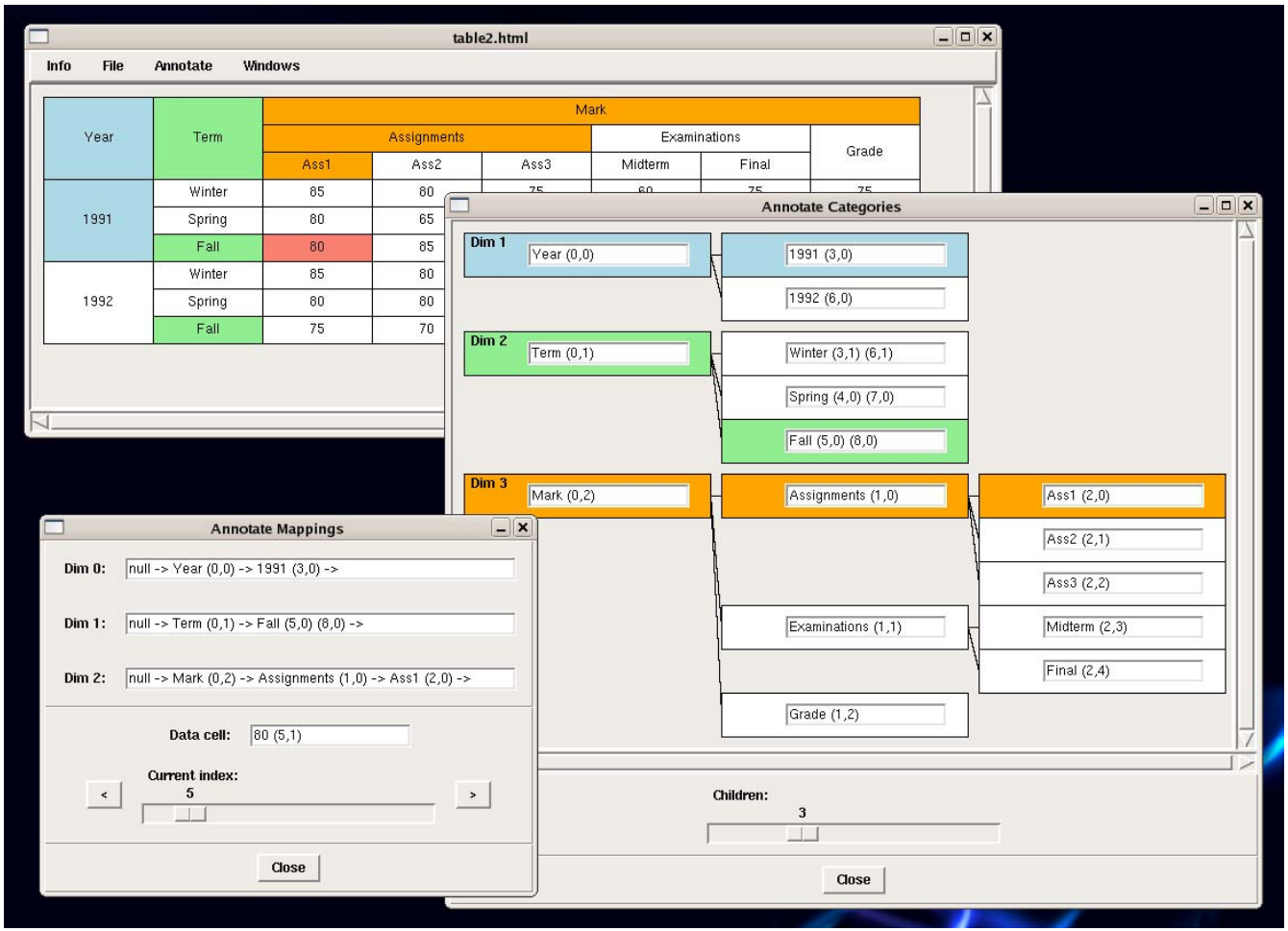


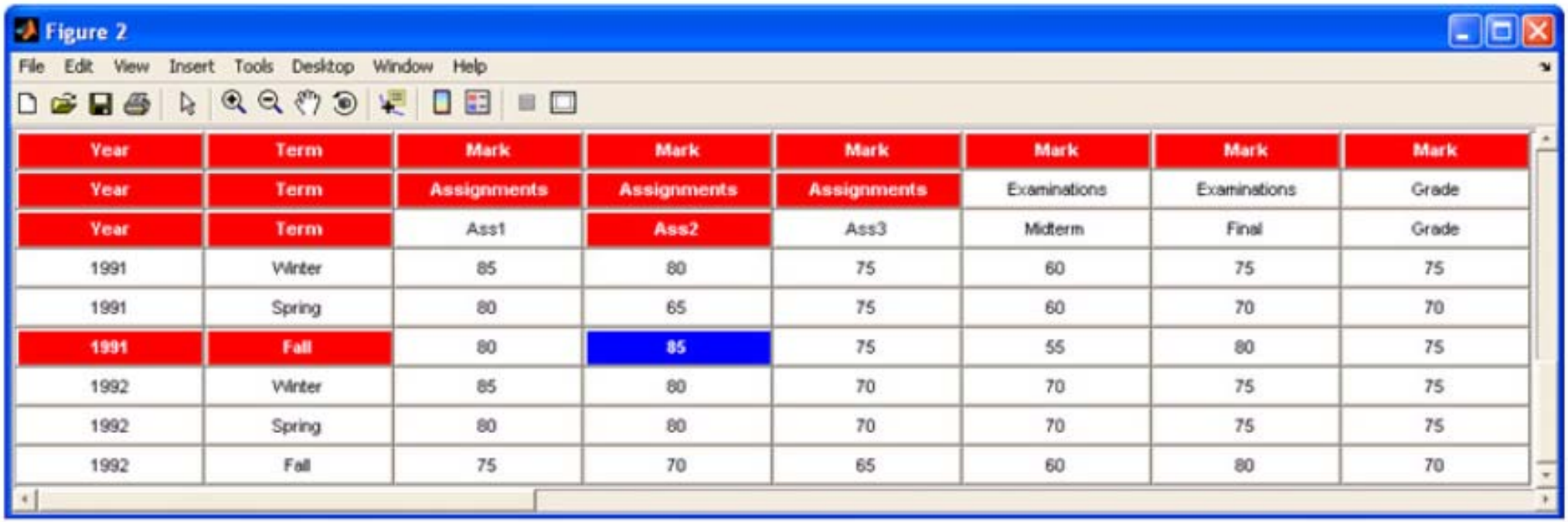
Table Annotation & Truthing

WNT:

Year	Term	Mark					
		Assignments			Examinations		Grade
		Ass1	Ass2	Ass3	Midterm	Final	
1991	Winter	85	80	75	60	75	75
	Spring	80	65	75	60	70	70
	Fall	80	85	75	55	80	75
1992	Winter	85	80	70	70	75	75
	Spring	80	80	70	70	75	75
	Fall	75	70	65	60	80	70

Table Annotation & Truthing

WNT (verification):

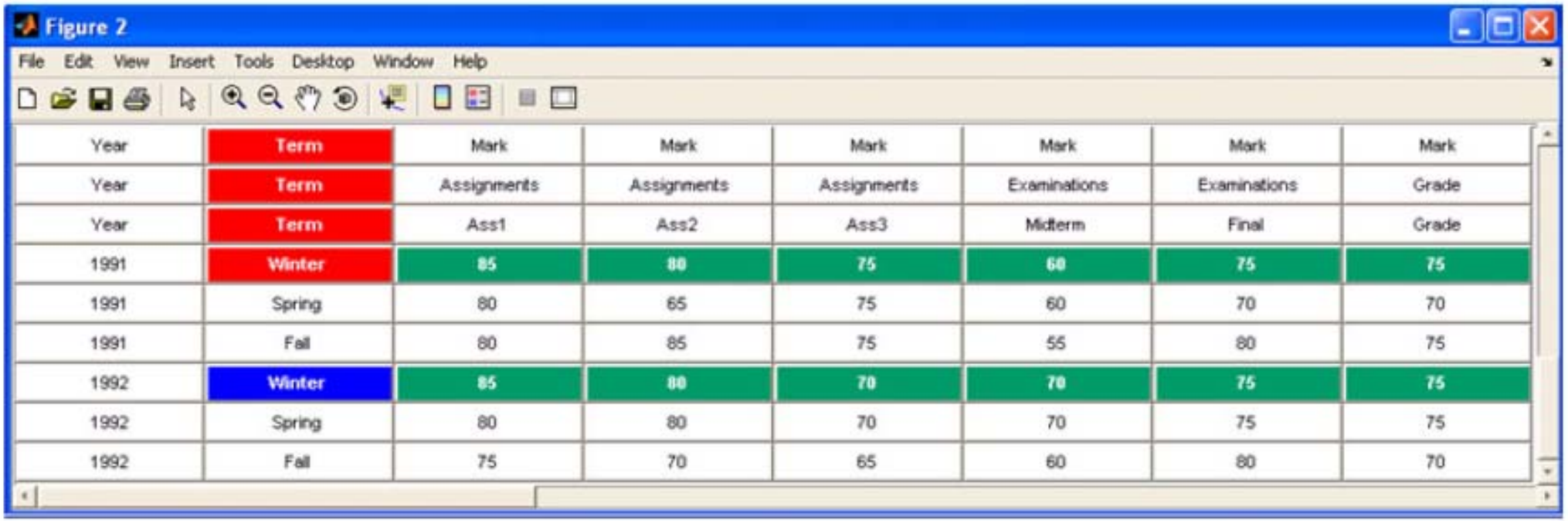


Year	Term	Mark	Mark	Mark	Mark	Mark	Mark
Year	Term	Assignments	Assignments	Assignments	Examinations	Examinations	Grade
Year	Term	Ass1	Ass2	Ass3	Midterm	Final	Grade
1991	Winter	85	80	75	60	75	75
1991	Spring	80	65	75	60	70	70
1991	Fall	80	85	75	55	80	75
1992	Winter	85	80	70	70	75	75
1992	Spring	80	80	70	70	75	75
1992	Fall	75	70	65	60	80	70

Figure 39: Verifying Delta Cell (1)

Table Annotation & Truthing

WNT (verification):



Year	Term	Mark	Mark	Mark	Mark	Mark	Mark
Year	Term	Assignments	Assignments	Assignments	Examinations	Examinations	Grade
Year	Term	Ass1	Ass2	Ass3	Midterm	Final	Grade
1991	Winter	85	80	75	60	75	75
1991	Spring	80	65	75	60	70	70
1991	Fall	80	85	75	55	80	75
1992	Winter	85	80	70	70	75	75
1992	Spring	80	80	70	70	75	75
1992	Fall	75	70	65	60	80	70

Figure 41: Verifying Category Cell (1)

Table Understanding

With domain knowledge? Ontology??

- Currently multon is the best value for rapitting velters. It is about 25% better than burlam or falder, which are nearly the same.
- Check Table II to see whether elmer is even better.

A Table Ontology

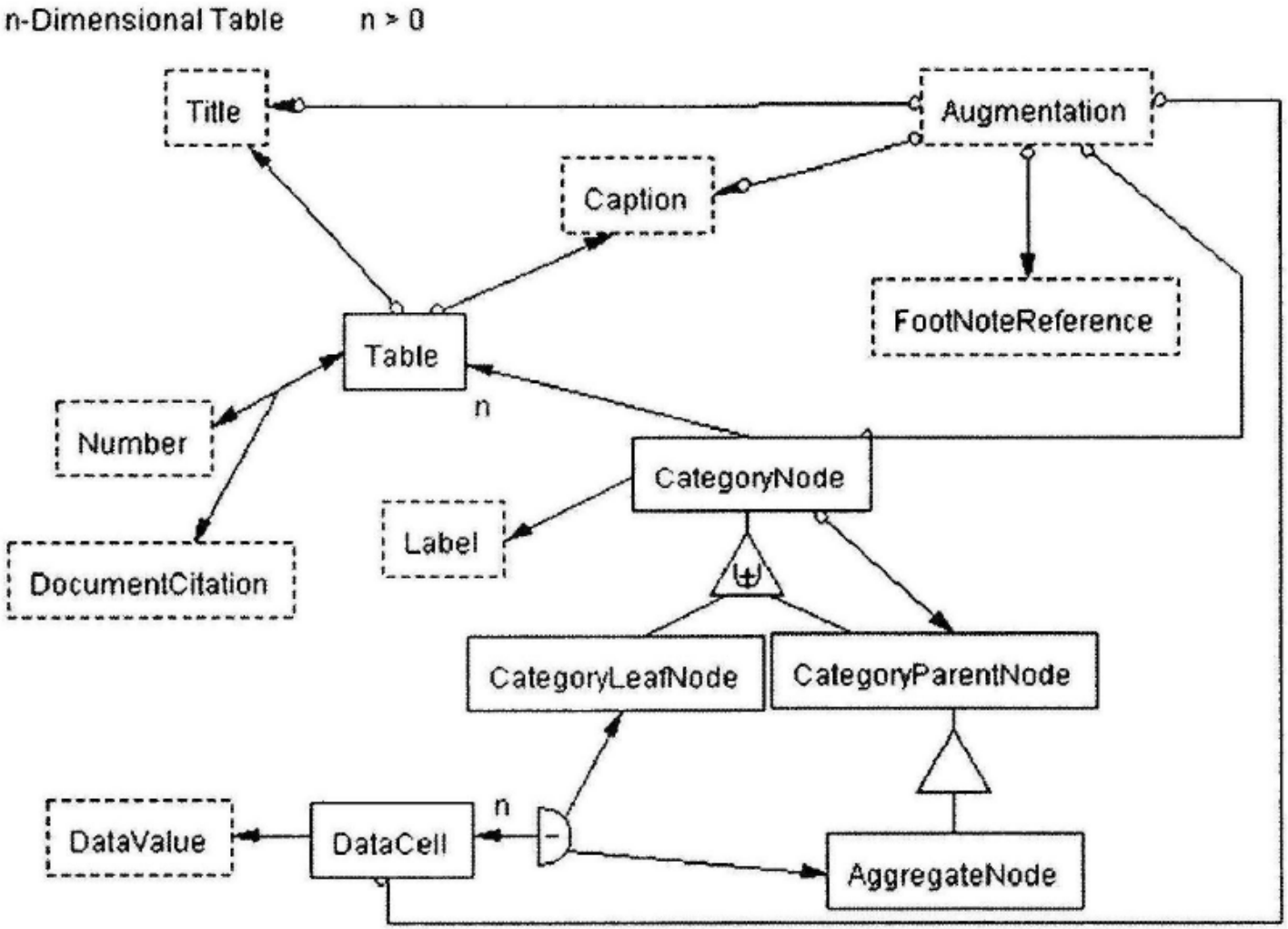


Figure 36: Ontology of a General Table

TANGO

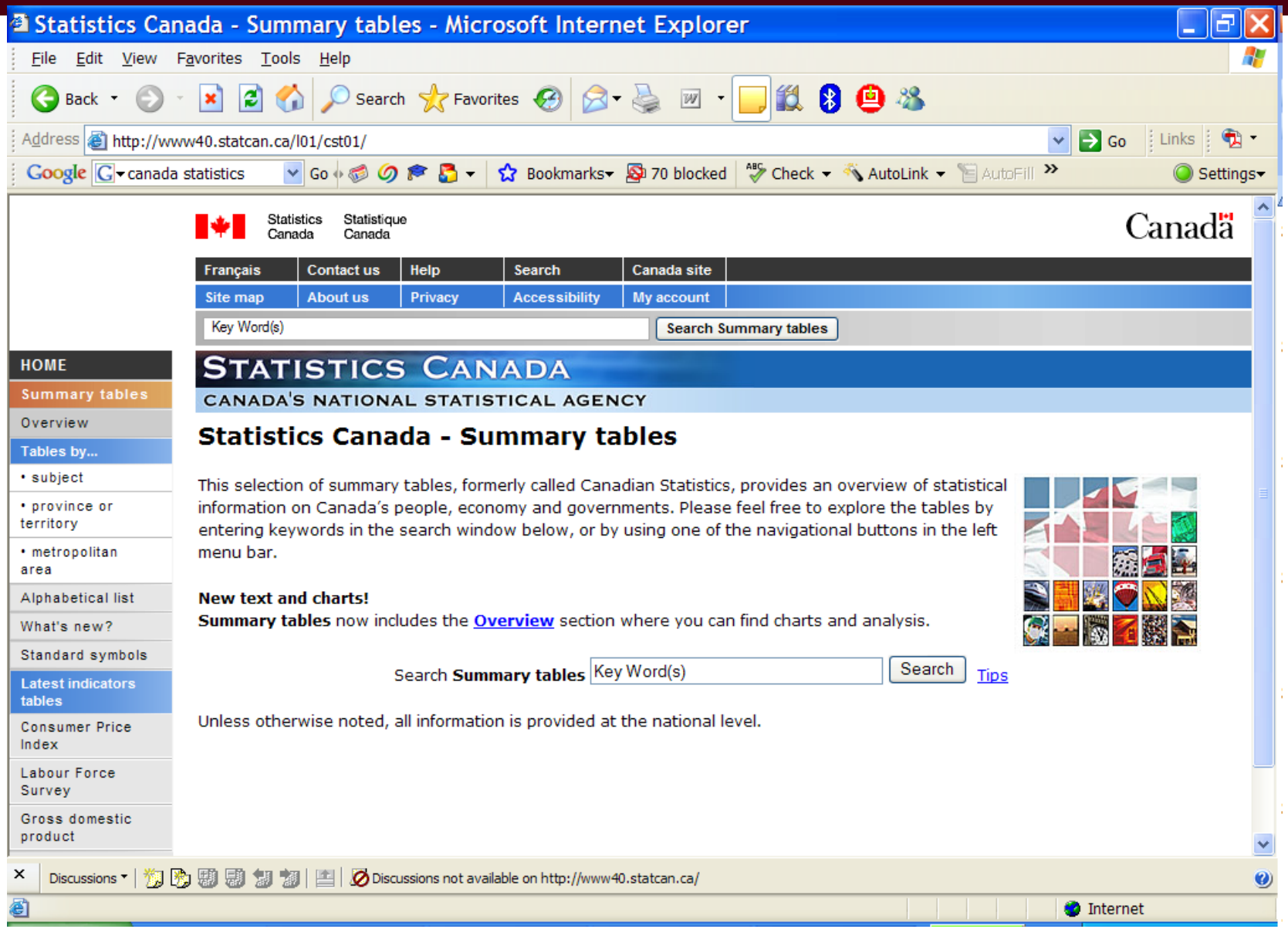
Table Analysis for Generating Ontologies
(with D.W. Embley and D. Lonsdale at BYU)
http://tango.byu.edu/

- Interpret raw tables
- Converts each table into a mini-ontology
- Integrate mini-ontologies into growing ontologies
  that represent domain concepts, relationships, and constraints in the already processed tables.

Domains:

obituaries, census records, automobile ads, genetics, geo-politics

Our current source of tables



Perhaps next?

This week, **161** tables have been added…

Current Status

- Most previous work (>100 papers) on table layout analysis and transcription.
- Easier for tables in symbolic form (.doc, .xls, .pdf, html) than for scanned bitmaps.
- Most methods process only one table at a time.
- Commercial software already does it fairly well.
- Interaction required in many cases.
- The next step, in our view, is table interpretation.
- Table understanding is waiting in the wings.

Why is table processing so difficult?

- Tables are intended for human consumption
- Often the *content* of the table must be inferred from external knowledge
- The roots of category trees are often missing
- Tables are intrinsically asymmetrical
- Tables are often combined or split to suit layout constraints
- Understanding tables requires domain knowledge
- Some authors consider understanding tables harder
  understanding natural language
- Tables are not forms
  they are meant to disseminate information,
  whereas forms are designed to collect them,
- Web tables are often nested
- Web tables can be dynamic

Next: some examples of tables from

D. Lopresti and G. Nagy, "Automated table processing: an (opinionated) survey," *Proceedings of IAPR Workshop on Graphics Recognition (GREC99)*, pp. 109-134, Jaipur, India, September 1999.

D. Lopresti and G. Nagy, "A Tabular Survey of Table Processing," *Graphics Recognition -- Recent Advances*, A. K. Chhabra and D. Dori, Eds., Springer Lecture Notes in Computer Science #1941, pp. 93-120, 2000.

J. Hu, R. Kashi, D. Lopresti, G. Wilfong, and G. Nagy, "Why table ground-truthing is hard," *Proceedings of International Conference on Document Analysis and Recognition*, pp. 129-133, Seattle, WA, IEEE Computer Society Press, September 2001.

G. Nagy and D. Lopresti, "Issues in ground-truthing graphic documents," *Lecture Notes in Computer Science*, pp. 46-66, Springer, 2002 (selected papers from the Fourth International Workshop on Graphics Recognition).

S. Veeramachaneni and G. Nagy, "Style context with second order statistics," *IEEE Transactions on Pattern Analysis and Machine Intelligence*, vol. 27, #1, pp. 14-22, January 2005.

D. Lopresti, D.W. Embley, M. Hurst, and G. Nagy, "Table Processing Paradigms: A Research Survey," *International Journal of Document Analysis and Recognition*, vol 8, no. 2-3, pp. 66-86, Springer, June 2006.

Table of tabular Q & A

Why tables?	Prevalent means of communicating structured data Content may include words, numbers, formulas, even graphics Metadata represented by alignment and rulings Adapted to computerized composition Underlying paradigm for spreadsheets and relational databases Bridge between textual and graphic representations
What is a table?	2-D cell assembly for presenting information Regular, repetitive structure along at least one axis [41] Datatype determined by either horizontal or vertical index
What is a form?	Isothetic layout for collecting information One-to-one mapping between indices and data No implication of regularity [41]
What is table analysis?	Information extraction follows table detection and localization Geometric analysis to isolate cell contents Table structure determined simultaneously If needed, OCR translates cells and headers into symbolic form Interpretation requires understanding context
Rationale for this study	Importance of converting tables from one medium to another Rapid growth of tables in various digital formats Desirability of medium-independent query algorithms Interdependence of table composition and interpretation Advent of new applications that require table interpretation Need for research to address neglected table topics

Table of table analysis methods

TABLE 1
A BRIEF SURVEY OF GEOMETRIC PAGE-LAYOUT ANALYSIS METHODS

No.	Author	Year	Approach	Features
1	Wahl et al. [11]	1982	Run length smoothing	Time consuming and skew sensitive
2	Nagy et al. [12]	1984	X-Y tree cut	Skew sensitive; Assumes rectangular blocks
3	Wang et al. [13]	1989	Run length smoothing and recursive X-Y cut	Newspaper analysis; Sensitive to skew
4	Fujisawa et al. [14]	1990	Top-down	Japanese patent documents
5	Fisher et al. [15]	1990	Run length smoothing and connected component extraction	Identifies text and nontext zones; Skew sensitive
6	Pavlidis et al. [16]	1991	Column oriented projection	Identifies text and nontext regions; Accommodates moderate skew
7	Baird [17]	1992	Global-to-local strategy	Accommodates different languages; Skew correction;
8	Jain et al. [18]	1992	Gabor filtering	Multichannel texture features from gray-scale images; Time consuming
9	Lebourgeois et al. [19]	1992	8× 3 window filtering	Unconstrained documents; Skew not considered
10	Pavlidis et al. [20]	1992	Horizontal smearing and bottom-up	Accommodates small skew; Fixed parameters
11	Akindele et al. [21]	1993	White space tracing	Polygonal blocks; Only text zones considered
12	Amamoto et al. [22]	1993	Morphological operation on white space	Identifies horizontal and vertical writing; Skew not considered
13	Ittner et al. [23]	1993	White space and minimum spanning tree	Language and orientation free; Large computation
14	O'Gorman [24]	1993	*k*-nearest neighbor clustering	Can handle arbitrary orientation with high accuracy; Large computation
15	Antonacopoulos et al. [25], [26]	1994	Contours from white tiles	Finds nonrectangular and skewed regions; Error in classifying large fonts
16	Zlatopolsky [27]	1994	Connected component extraction	Multiple skewed document; Sensitive parameters
17	Doermann [28]	1995	Wavelet multiscale analysis	Segments nonblock-nested pages; Gray-scale image processing; High computational complexity
18	Drivas et al. [29]	1995	Connected component grouping	Skew correction with a time consuming algorithm
19	Ha et al. [30]	1995	Connected component-based projection profile	Faster than pixel-based projection profile; Skew sensitive
20	Sylwester et al. [31]	1995	trainable X-Y cut	Relatively robust; Skew and noise free
21	Tang et al. [32]	1995	Modified fractal signature	Handles documents with high geometrical complexity; Gray-scale image processing; Time consuming
22	Jain et al. [33], [34]	1996	Masks and neural network	Handles documents with multiple languages; Gray-scale image processing; Time consuming
23	Kise et al. [35]	1996	Background thinning	Skewed nonrectangular layout; Bounding box is not very tight
24	Liu et al. [36]	1996	Adaptive top-down and bottom-up	Nonrectangular regions; Skew free
25	Yamashita et al. [37]	1996	Run length smearing and adaptive thresholding	Less sensitive to font size and spacing; Skew free

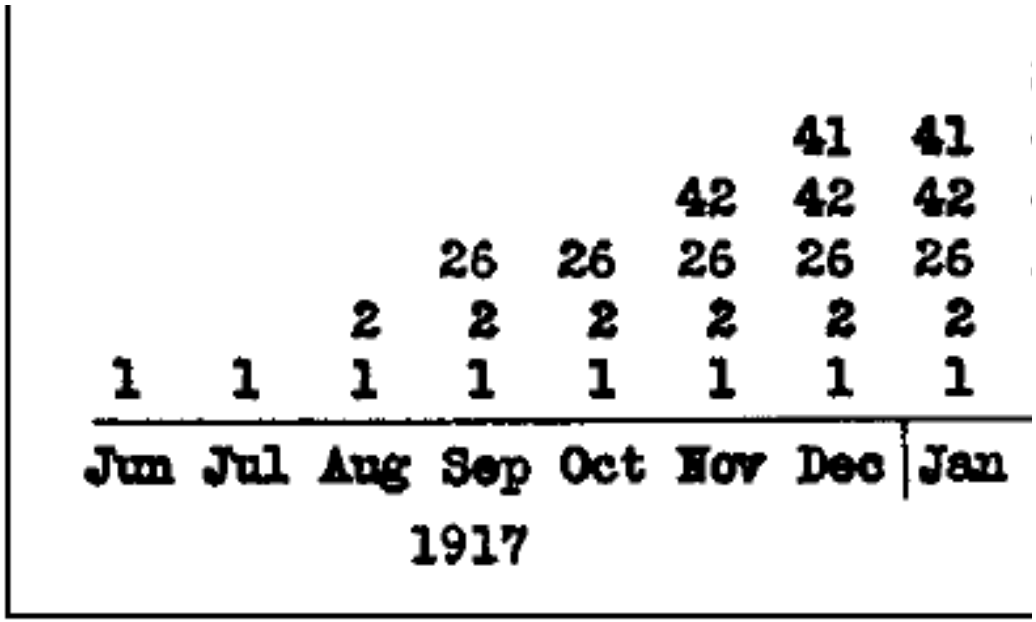
1-D or 2-D?

NAME		ADDRESS					TELNO		
First	Last	#	Street	City	State	Zip	Area-Code	#	Extension
...		...					...		

Small table

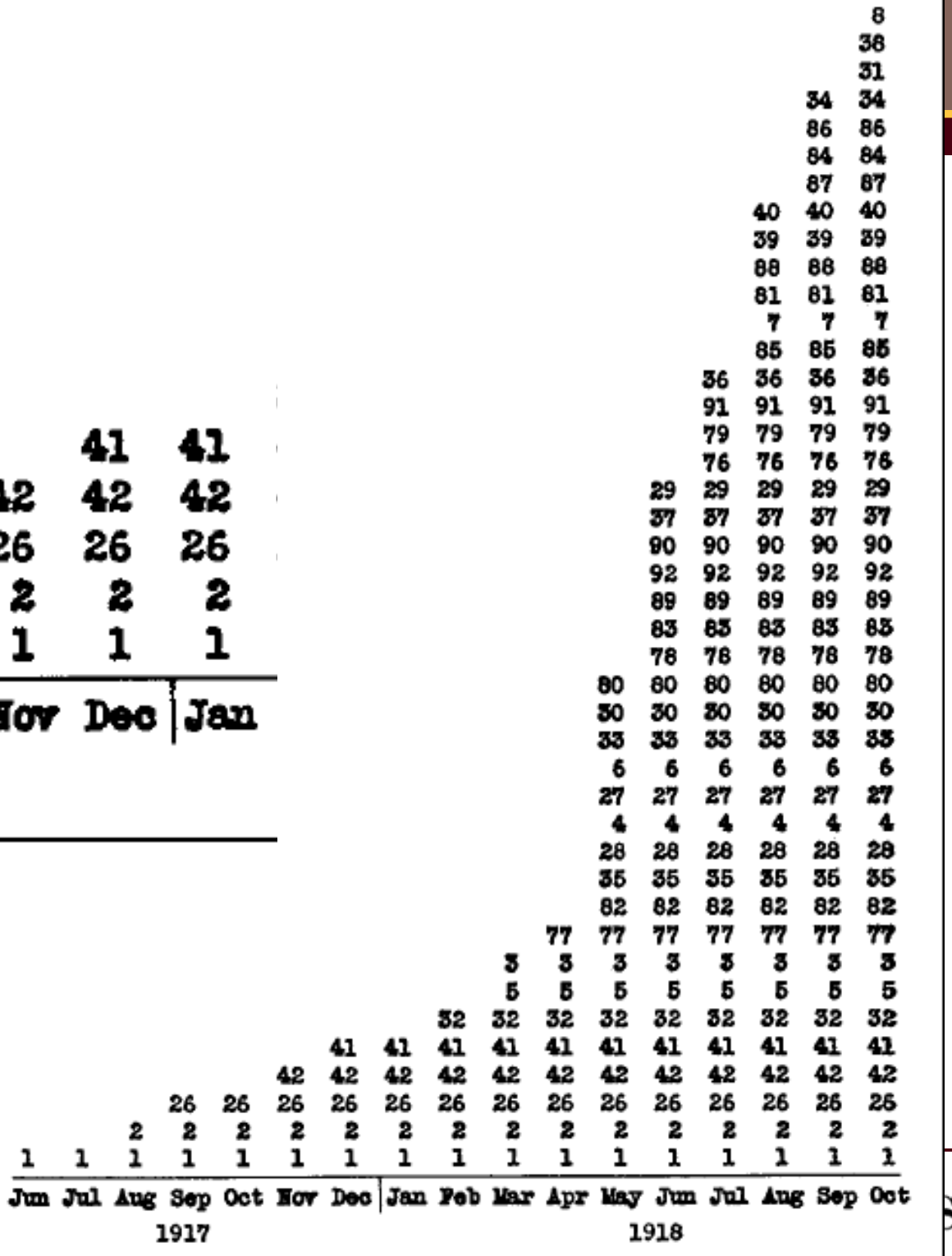

CASIO
DATA BANK 150
ILLUMINATOR
ADJUST
MODE
SHIFT
C/AC/SEARCH
TRIP
NEXT
WEEK
S M T W T F S
MON '99 8-16
P
7:02 33
MEMORY PROTECT
LIGHT
SCHEDULE
TELEMEMO
+/MC
×/MR
−/M−
+/M+

A triangular table!



Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan
1	1	1	1	1	1	1	1
		2	2	2	2	2	2
			26	26	26	26	26
					42	42	42
						41	41

1917



Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
		2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
			26	26	26	26	26	26	26	26	26	26	26	26	25	25
					42	42	42	42	42	42	42	42	42	42	42	42
						41	41	41	41	41	41	41	41	41	41	41
								32	32	32	32	32	32	32	32	32
									5	5	5	5	5	5	5	5
										3	3	3	3	3	3	3
											77	77	77	77	77	77
												82	82	82	82	82
												35	35	35	35	35
												28	28	28	28	28
												4	4	4	4	4
												27	27	27	27	27
												6	6	6	6	6
												33	33	33	33	33
												30	30	30	30	30
												80	80	80	80	80
													78	78	78	78
													83	83	83	83
													89	89	89	89
													92	92	92	92
													90	90	90	90
													37	37	37	37
													29	29	29	29
														76	76	76
														79	79	79
														91	91	91
														36	36	36
															85	85
															7	7
															81	81
															88	88
															39	39
															40	40
																87
																84
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																34
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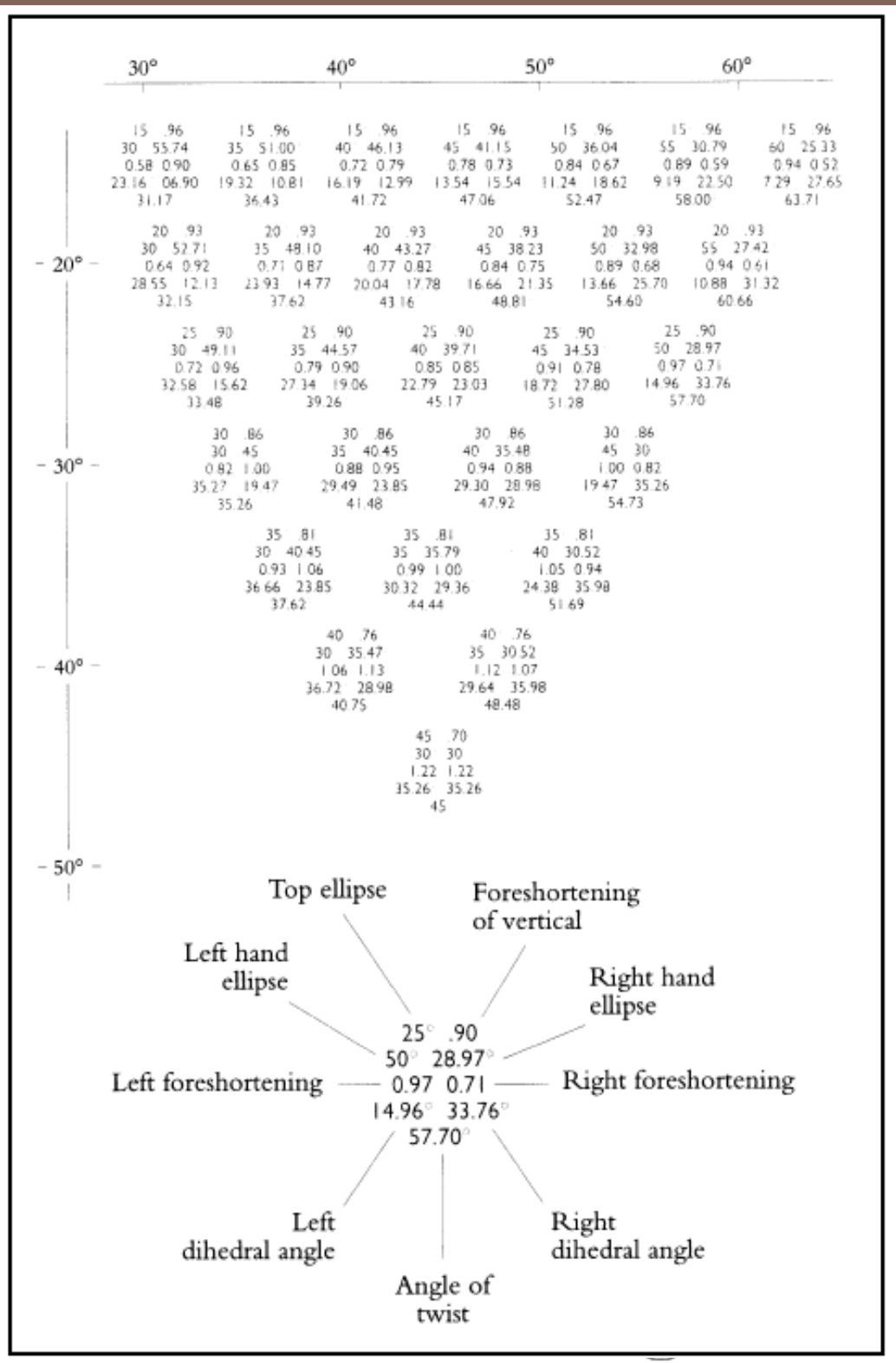
																38
																8

1917 1918

selaer

At the limit of tablehood

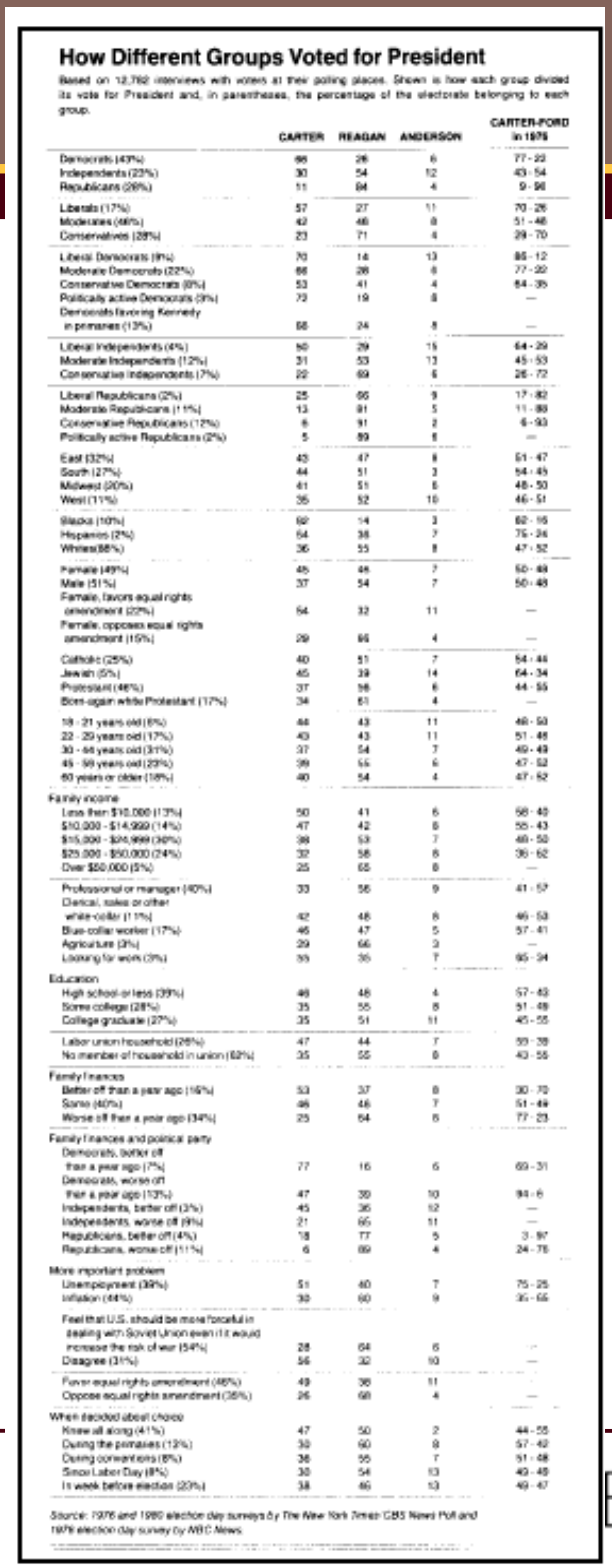


Many tables combined

How Different Groups Voted for President

Based on 12,782 interviews with voters at their polling places. Shown is how each group divided its vote for President and, in parentheses, the percentage of the electorate belonging to each group.

	CARTER	REAGAN	ANDERSON	CARTER-FORD in 1976
Democrats (43%)	66	26	6	77 - 22
Independents (23%)	30	54	12	43 - 54
Republicans (28%)	11	84	4	9 - 90
Liberals (17%)	57	27	11	70 - 26
Moderates (46%)	42	48	8	51 - 46
Conservatives (28%)	23	71	4	29 - 70
Liberal Democrats (9%)	70	14	13	86 - 12
Moderate Democrats (22%)	66	28	6	77 - 22
Conservative Democrats (8%)	53	41	4	64 - 35
Politically active Democrats (3%)	72	19	8	—



How Different Groups Voted for President

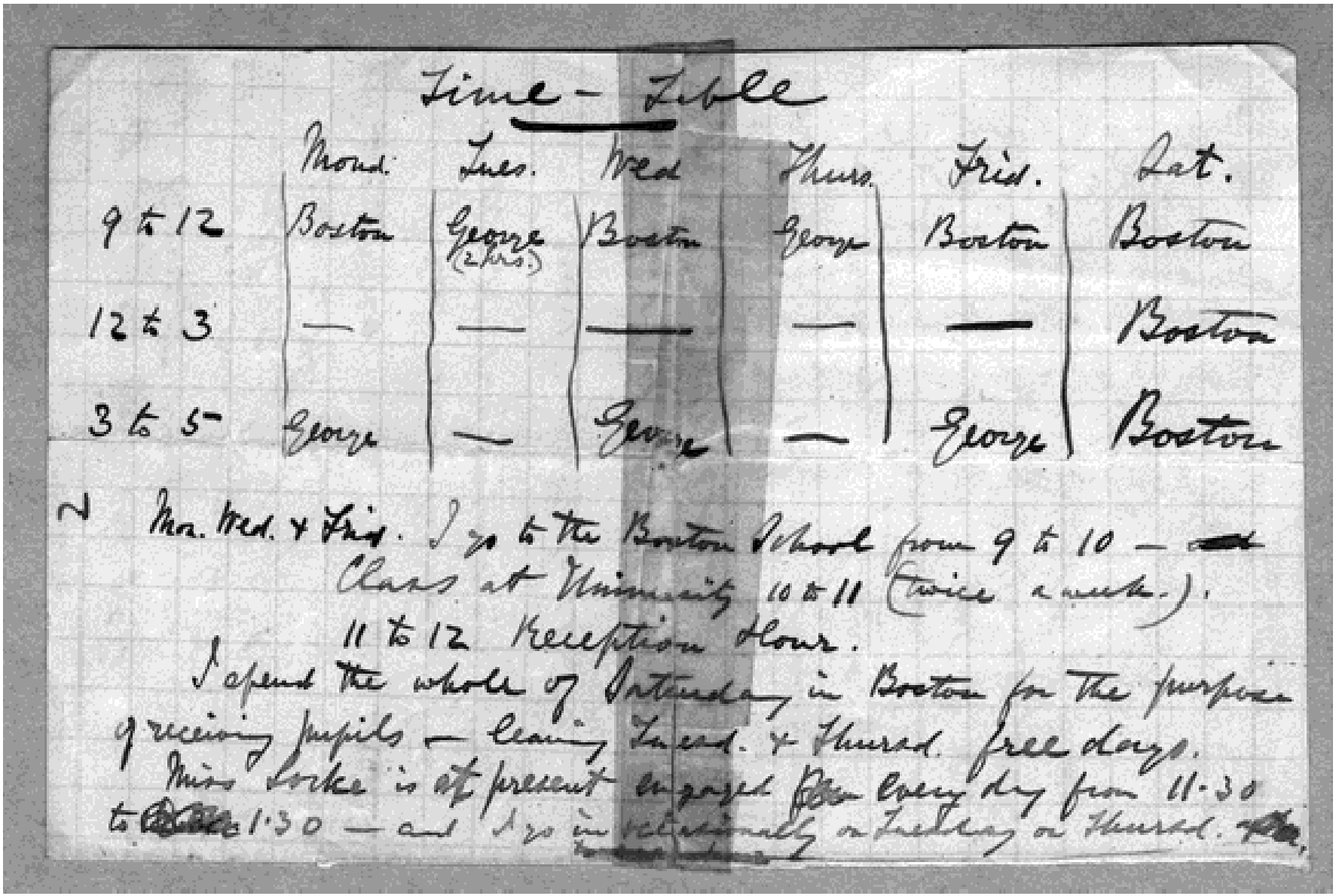
Based on 12,782 interviews with voters at their polling places. Shown is how each group divided its vote for President and, in parentheses, the percentage of the electorate belonging to each group.

Rensselaer

Simple, but is it computer understandable?

Monday, September 20, 1999			
	Track A Convention Hall A	Track B Convention Hall B	Track C Chanakya Hall
08:30 10:00	OPENING SESSION (Mo-1) Banquet Hall		
10:00	COFFEE BREAK Pool Side		
10:30 12:30	MULTIMEDIA DOCUMENT PROCESSING Mo-2A	CHARACTER RECOGNITION Mo-2B	DOCUMENT IMAGE PROCESSING - I Mo-2C
12:30	LUNCH Pool Side		
13:30 14:30	POSTER PRESENTATION Mo-3A	POSTER PRESENTATION Mo-3B	POSTER PRESENTATION Mo-3C
13:30 15:30	POSTER SESSION - I (Mo-3) Banquet Hall (Coffee served at 14:30)		
15:30 17:30	INFORMATION RETRIEVAL Mo-4A	POSTAL AUTOMATION Mo-4B	FONT RECOGNITION Mo-4C
19:00 21:00	CONFERENCE RECEPTION Banquet Hall		

Bell Table



Time - Table

	Mond.	Tues.	Wed	Thurs.	Frid.	Sat.
9 to 12	Boston	George (2 hrs.)	Boston	George	Boston	Boston
12 to 3	—	—	—	—	—	Boston
3 to 5	George	—	George	—	George	Boston

N Mon. Wed. & Fri. I go to the Boston School from 9 to 10 — Class at University 10 to 11 (twice a week.).
11 to 12 Reception Hour.
I spend the whole of Saturday in Boston for the purpose of receiving pupils — leaving Tues. & Thurs. free days.
Miss Locke is at present engaged from 11.30 to 1.30 — and I go in relation only on Tuesday or Thurs.

Split table

1996 DDVPC 2400bps Candidate Coder Intellibility Performance Calibrations

DRT	Wgt 0.35	Wgt	Wgt	A A(M)	A A(F)	A A(C)	A A(SE)	B B(M)	B B(F)	B B(C)	B B(SE)	C C(M)	C C(F)	C C(C)	C C(SE)	D D(M)	D D(F)	D D(C)	D D(SE)
Quiet	0.20	0.100		90.8	88.9	89.9	0.55	90.1	90.8	90.5	0.48	93.8	90.8	92.3	0.70	92.7	90.1	91.4	0.71
Vinson Quiet		0.100		91.5	91.4	91.4	0.42	91.4	88.4	89.9	0.83	91.3	91.1	91.2	0.78	92.1	89.4	90.8	0.57
Office	0.60	0.067		91.8	91.2	91.5	0.91	88.6	88.2	88.4	0.55	91.5	91.0	91.2	0.75	92.4	89.8	91.1	0.59
Auto		0.067		87.9	77.6	82.7	0.93	86.3	79.2	82.7	0.91	86.8	79.9	83.4	0.81	87.5	81.3	84.4	0.88
Humvee		0.067		61.8	66.9	64.4	1.06	64.8	64.9	64.8	1.30	61.8	64.4	63.1	0.72	61.2	69.6	65.4	0.62
M2 Bradley		0.067		67.4	67.1	67.3	1.36	66.3	68.8	67.6	0.88	61.4	67.2	64.3	1.17	66.0	67.1	66.6	0.71
Helicopter		0.067		61.5	68.5	65.0	1.15	68.6	68.9	68.7	1.07	63.5	69.9	66.7	0.61	66.2	71.2	68.7	1.04
F-15		0.067		74.9	78.1	76.5	0.85	71.1	71.1	71.1	0.52	77.5	76.7	76.7	0.91	73.4	75.2	74.3	0.57
E3A		0.067		87.6	83.0	85.3	0.75	86.9	84.8	85.9	0.81	89.5	85.5	87.5	0.85	89.1	83.8	86.5	0.66
P3C		0.067		89.2	82.2	85.7	0.71	87.4	81.5	84.4	0.75	84.5	85.4	85.4	0.59	87.3	81.9	84.6	0.88
MCE		0.067		88.5	88.4	88.5	0.72	86.7	87.5	87.1	0.77	89.0	90.6	89.8	1.08	86.6	88.9	87.8	0.84
BER	0.10	0.050		86.2	82.6	84.4	0.89	88.5	85.7	87.1	0.52	88.6	89.2	88.9	0.63	87.2	86.1	86.7	0.71
BLER		0.050		92.3	89.7	91.0	0.86	92.4	89.7	91.1	0.63	93.4	90.0	91.7	0.64	90.2	88.2	89.2	0.45
S_Tandem	0.10	0.050		85.0	85.3	85.2	0.73	87.4	84.3	85.9	0.60	87.5	84.5	86.0	0.72	87.6	84.7	86.2	0.71
D_Tandem		0.050		84.1	81.9	83.0	0.86	83.0	78.0	80.5	0.62	85.2	80.6	82.9	0.58	84.3	81.2	82.8	0.75
Intell. Perf				82.984	81.872	82.437	0.261	82.829	81.132	81.984	0.293	83.279	82.779	83.032	0.241	83.259	82.214	82.759	0.217
	1.00	1.000		A(M)	A(F)	A(C)	A(SE)	B(M)	B(F)	B(C)	B(SE)	C(M)	C(F)	C(C)	C(SE)	D(M)	D(F)	D(C)	D(SE)
Rank				4	4	4		5	6	5		2	2	2		3	3	3	

1996 DDVPC 2400bps Reference Coder Intellibility Performance Calibrations

DRT	Wgt 0.35	Wgt	Wgt	CELP Celp(M)	CELP Celp(F)	CELP Celp(C)	CELP Celp(SE	CVSD KY(M)	CVSD KY(F)	CVSD KY(C)	CVSD KY(SE)	LPC LPC(M)	LPC LPC(F)	LPC LPC(C)	LPC LPC(SE)
Quiet	0.20	0.100		90.9	90.5	90.7	0.34	88.2	88.8	88.5	0.85	87.3	85.1	86.2	0.60
Vinson Quiet		0.100		91.9	90.3	91.1	0.44	91.4	90.2	90.8	0.66	81.9	82.7	82.3	0.65
Office	0.60	0.067		89.8	88.3	89.0	0.88	89.6	88.1	88.8	0.50	84.8	85.5	85.2	0.81
Auto		0.067		88.9	83.3	86.1	0.85	89.0	84.8	86.9	1.02	73.1	63.7	68.4	0.73
Humvee		0.067		60.6	65.4	63.0	0.95	65.2	73.3	69.3	1.33	21.7	41.7	31.7	2.26
M2 Bradley		0.067		60.7	66.9	63.8	1.14	74.3	78.4	76.4	0.94	34.2	42.5	38.4	1.27
Helicopter		0.067		61.0	66.6	63.8	0.94	75.6	78.9	77.2	0.78	39.4	55.8	47.6	1.24
F-15		0.067		73.0	75.5	74.3	0.79	74.7	78.6	76.6	1.11	70.5	69.4	69.9	0.88
E3A		0.067		84.6	85.6	85.0	0.62	88.2	89.9	89.0	0.94	66.7	65.3	66.0	1.09
P3C		0.067		85.7	82.7	84.2	1.19	89.5	86.0	87.7	0.72	80.9	78.5	79.7	1.00
MCE		0.067		90.5	87.8	89.1	0.96	90.8	90.0	90.4	0.75	77.5	78.7	78.1	1.10
BER	0.10	0.050		90.3	86.0	88.2	0.73	86.1	87.8	86.9	0.67	80.0	82.7	81.4	0.90
BLER		0.050		87.1	89.3	88.2	0.96	86.8	85.6	86.2	0.78	85.2	82.9	84.0	0.72
S_Tandem	0.10	0.050		84.8	83.7	84.3	0.61	89.0	87.3	88.2	1.03	75.8	75.5	75.6	1.10
D_Tandem		0.050		83.0	80.6	81.8	0.96	84.4	85.9	85.2	0.70	72.0	73.5	72.7	0.64
Intell. Perf				81.860	81.867	81.859	0.260	84.402	85.097	84.742	0.297	69.157	71.250	70.202	0.332
	1.00	1.000		Celp(M)	Celp(F)	Celp(C)	Celp(SE	KY(M)	KY(F)	KY(C)	KY(SE)	LPC(M)	LPC(F)	LPC(C)	LPC(SE)
Rank				6	5	6		1	1	1		7	7	7	

Where does it begin and end?

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******************************************************
              LUCENT TECHNOLOGIES TODAY
         For the People of Lucent Technologies
                Friday, February 12, 1999
******************************************************

                  ***  STOCK WATCH  ***

                TODAY'S    YESTERDAY'S    YESTERDAY'S
                 OPEN         CLOSE          CHANGE

Lucent          100 13/16  101 1/16       + 3 13/16
Ascend          73 5/8     74 7/8         + 2 3/8
AT&T            87 1/2     88 3/16        + 2 3/8
Alcatel         21 7/8     22             + 13/16
Ericsson        26 1/4     26 3/8         + 1 5/16
Motorola        67 1/2     67 1/4         + 1 13/16
DJIA            9367.32    9363.46        + 186.15
NASDAQ          2375.99    2405.55        + 96.05

******************************************************

*** NEWS IN A NUTSHELL ***       *** LUCENT HERITAGE ***

* New software tool              On Feb. 17, 1998, Lucent
* America's most admired         announced that it would
* Switch lands in winter games   acquire Hewlett-Packard's
* Students visit Bell Labs       local multipoint distribution
* World of Science Seminars      service wireless business
* Client feedback survey         and launch a new Wireless
                                 Broadband Networks Division.

***************  LUCENT IN THE NEWS  ****************

STUDENTS VISIT BELL LABS -- Hosted by Lucent Korea,
elementary school students from Korea visited Bell Labs
in New Jersey to explore its advanced science and
technology.  Lucent Korea provided the six-day tour for
the students to encourage their education in science.
[Naeway Economic Daily (Korea), 2/12]
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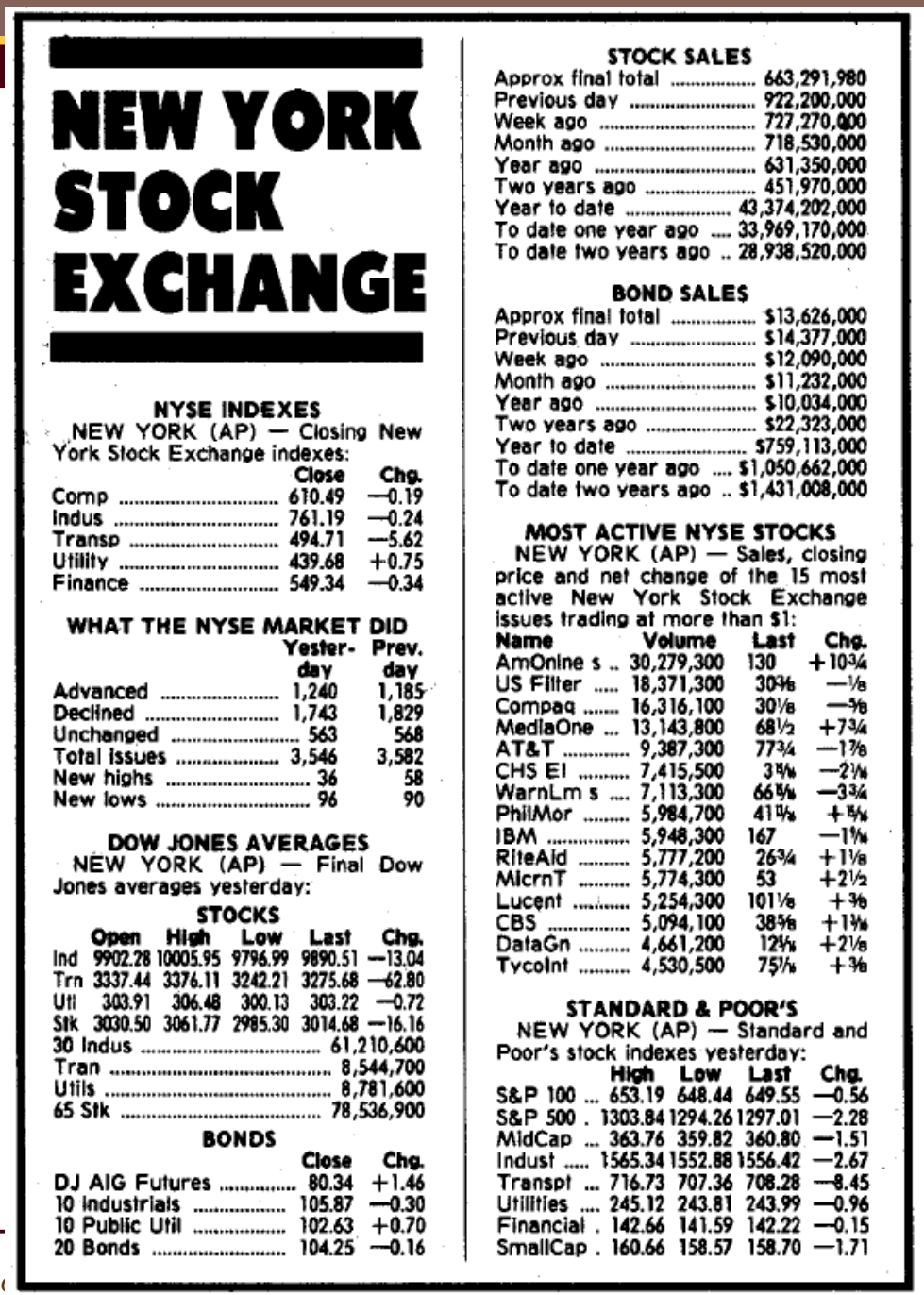
How many tables?



NEW YORK STOCK EXCHANGE

NYSE INDEXES

NEW YORK (AP) — Closing New York Stock Exchange indexes:

	Close	Chg.
Comp	610.49	—0.19
Indus	761.19	—0.24
Transp	494.71	—5.62
Utility	439.68	+0.75
Finance	549.34	—0.34

WHAT THE NYSE MARKET DID

	Yester-day	Prev. day
Advanced	1,240	1,185
Declined	1,743	1,829
Unchanged	563	568
Total issues	3,546	3,582
New highs	36	58
New lows	96	90

DOW JONES AVERAGES

NEW YORK (AP) — Final Dow Jones averages yesterday:

STOCKS

	Open	High	Low	Last	Chg.
Ind	9902.28	10005.95	9796.99	9890.51	—13.04
Trn	3337.44	3376.11	3242.21	3275.68	—62.80
Utl	303.91	306.48	300.13	303.22	—0.72
Stk	3030.50	3061.77	2985.30	3014.68	—16.16

30 Indus	61,210,600
Tran	8,544,700
Utils	8,781,600
65 Stk	78,536,900

BONDS

	Close	Chg.
DJ AIG Futures	80.34	+1.46
10 Industrials	105.87	—0.30
10 Public Util	102.63	+0.70
20 Bonds	104.25	—0.16

STOCK SALES

Approx final total	663,291,980
Previous day	922,200,000
Week ago	727,270,000
Month ago	718,530,000
Year ago	631,350,000
Two years ago	451,970,000
Year to date	43,374,202,000
To date one year ago	33,969,170,000
To date two years ago	28,938,520,000

BOND SALES

Approx final total	$13,626,000
Previous day	$14,377,000
Week ago	$12,090,000
Month ago	$11,232,000
Year ago	$10,034,000
Two years ago	$22,323,000
Year to date	$759,113,000
To date one year ago	$1,050,662,000
To date two years ago	$1,431,008,000

MOST ACTIVE NYSE STOCKS

NEW YORK (AP) — Sales, closing price and net change of the 15 most active New York Stock Exchange issues trading at more than $1:

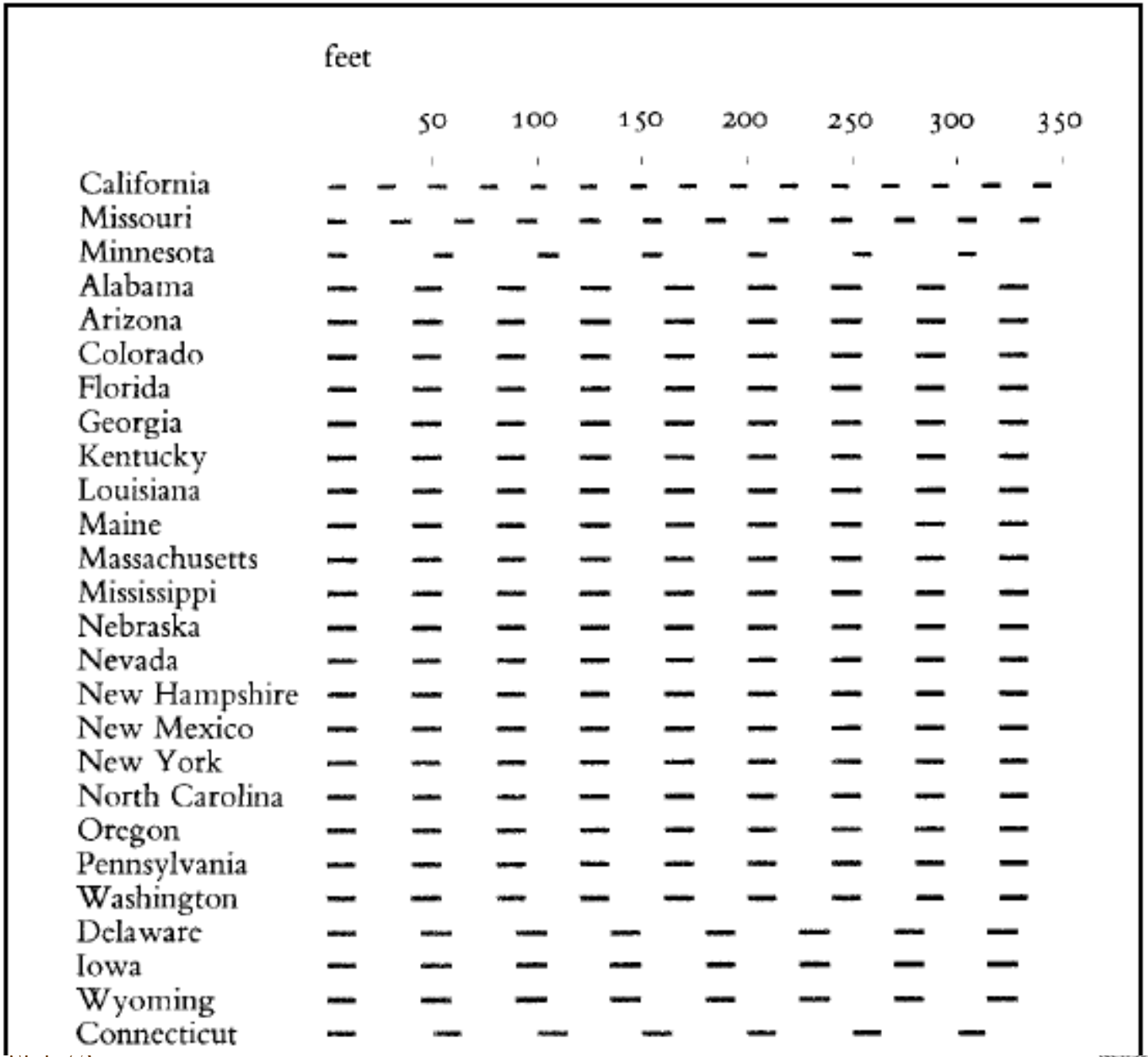
Name	Volume	Last	Chg.
AmOnline s	30,279,300	130	+10¾
US Filter	18,371,300	30⅜	—⅛
Compaq	16,316,100	30⅛	—⅜
MediaOne	13,143,800	68½	+7¾
AT&T	9,387,300	77¾	—1⅞
CHS El	7,415,500	3⅝	—2⅛
WarnLm s	7,113,300	66⅝	—3¾
PhilMor	5,984,700	41⅛	+⅝
IBM	5,948,300	167	—1⅛
RiteAid	5,777,200	26¾	+1⅛
MicrnT	5,774,300	53	+2½
Lucent	5,254,300	101⅛	+⅜
CBS	5,094,100	38⅝	+1⅛
DataGn	4,661,200	12⅛	+2⅛
TycoInt	4,530,500	75⅞	+⅜

STANDARD & POOR'S

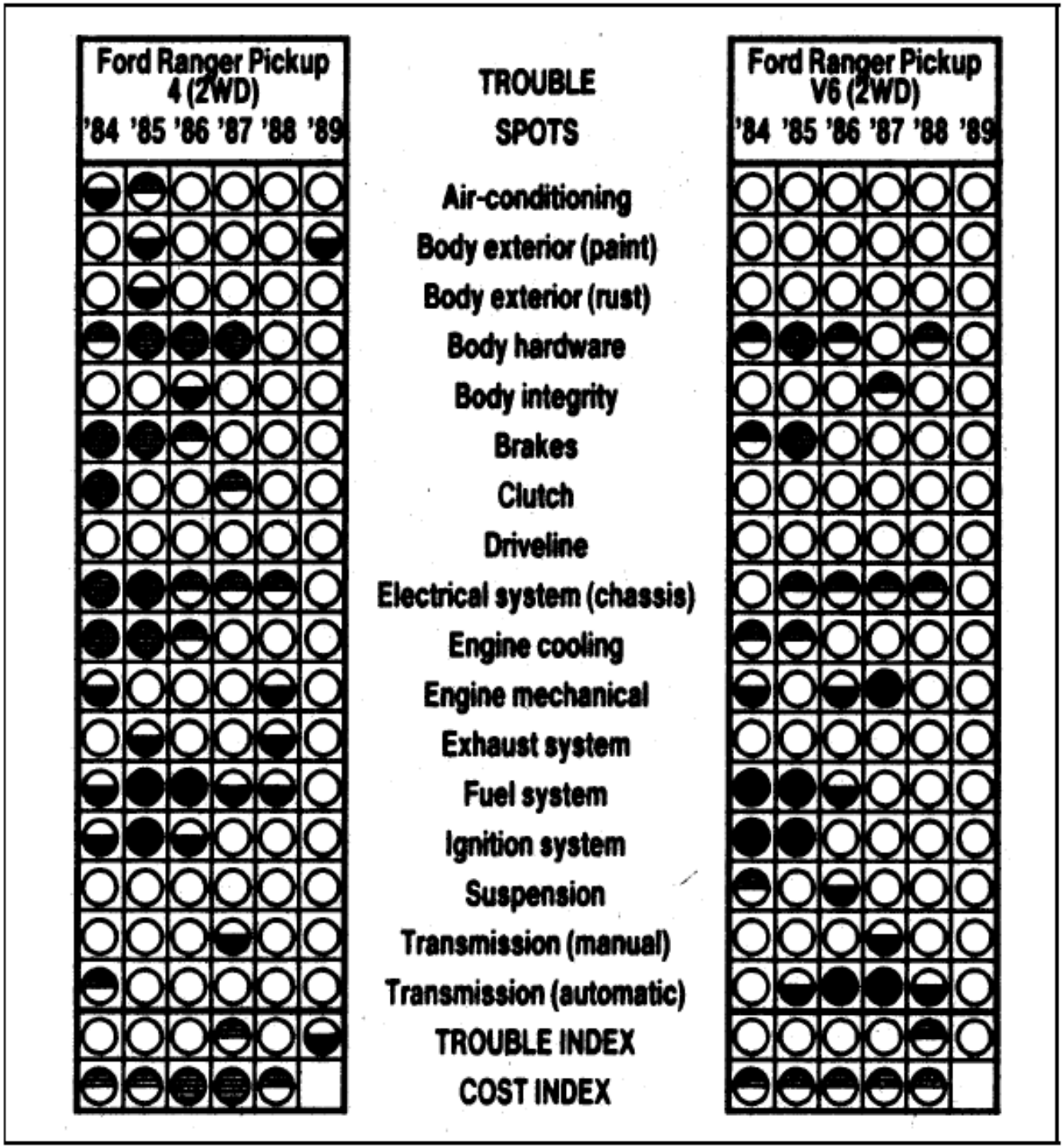
NEW YORK (AP) — Standard and Poor's stock indexes yesterday:

	High	Low	Last	Chg.
S&P 100	653.19	648.44	649.55	—0.56
S&P 500	1303.84	1294.26	1297.01	—2.28
MidCap	363.76	359.82	360.80	—1.51
Indust	1565.34	1552.88	1556.42	—2.67
Transpt	716.73	707.36	708.28	—8.45
Utilities	245.12	243.81	243.99	—0.96
Financial	142.66	141.59	142.22	—0.15
SmallCap	160.66	158.57	158.70	—1.71

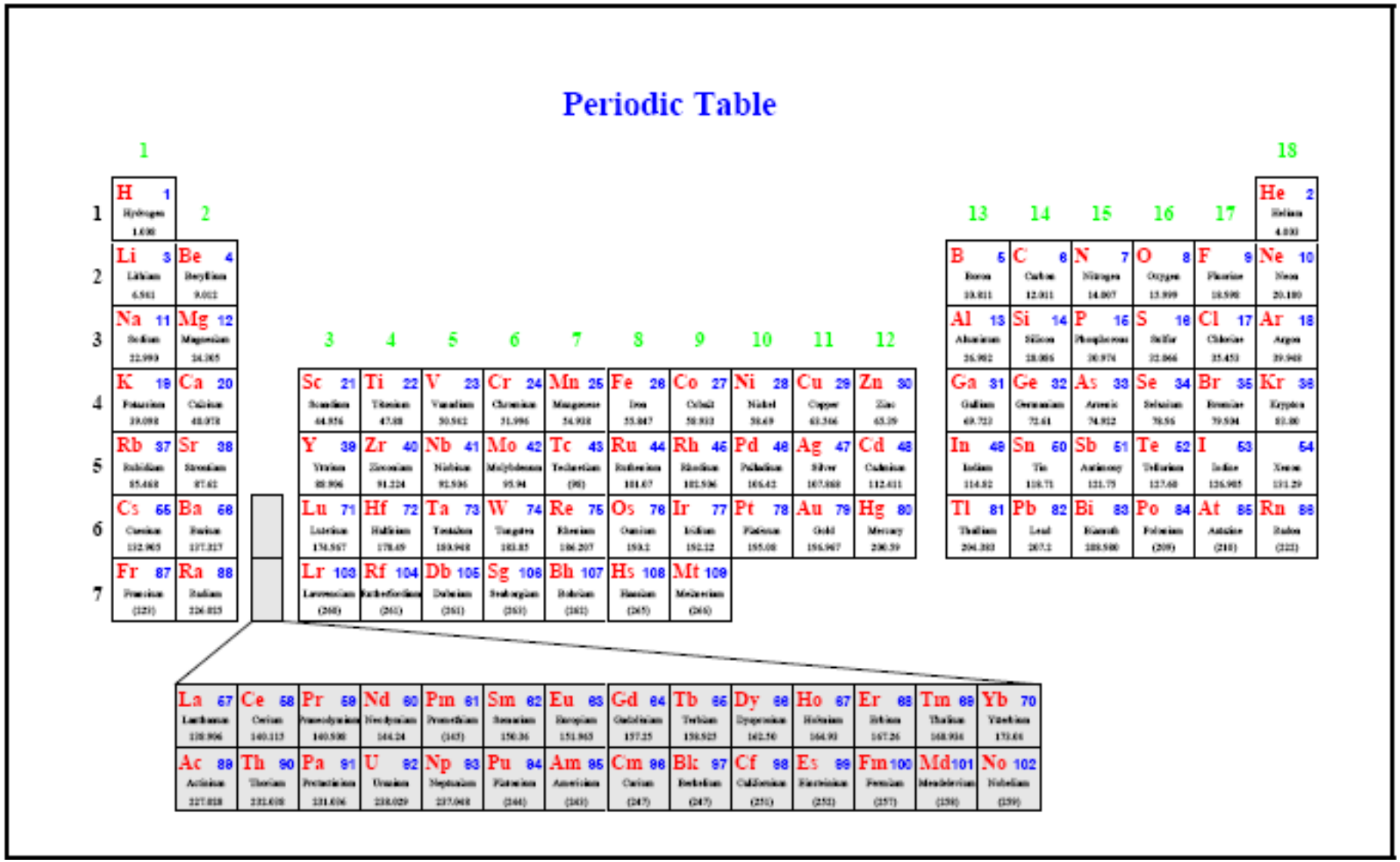
What does this table show?



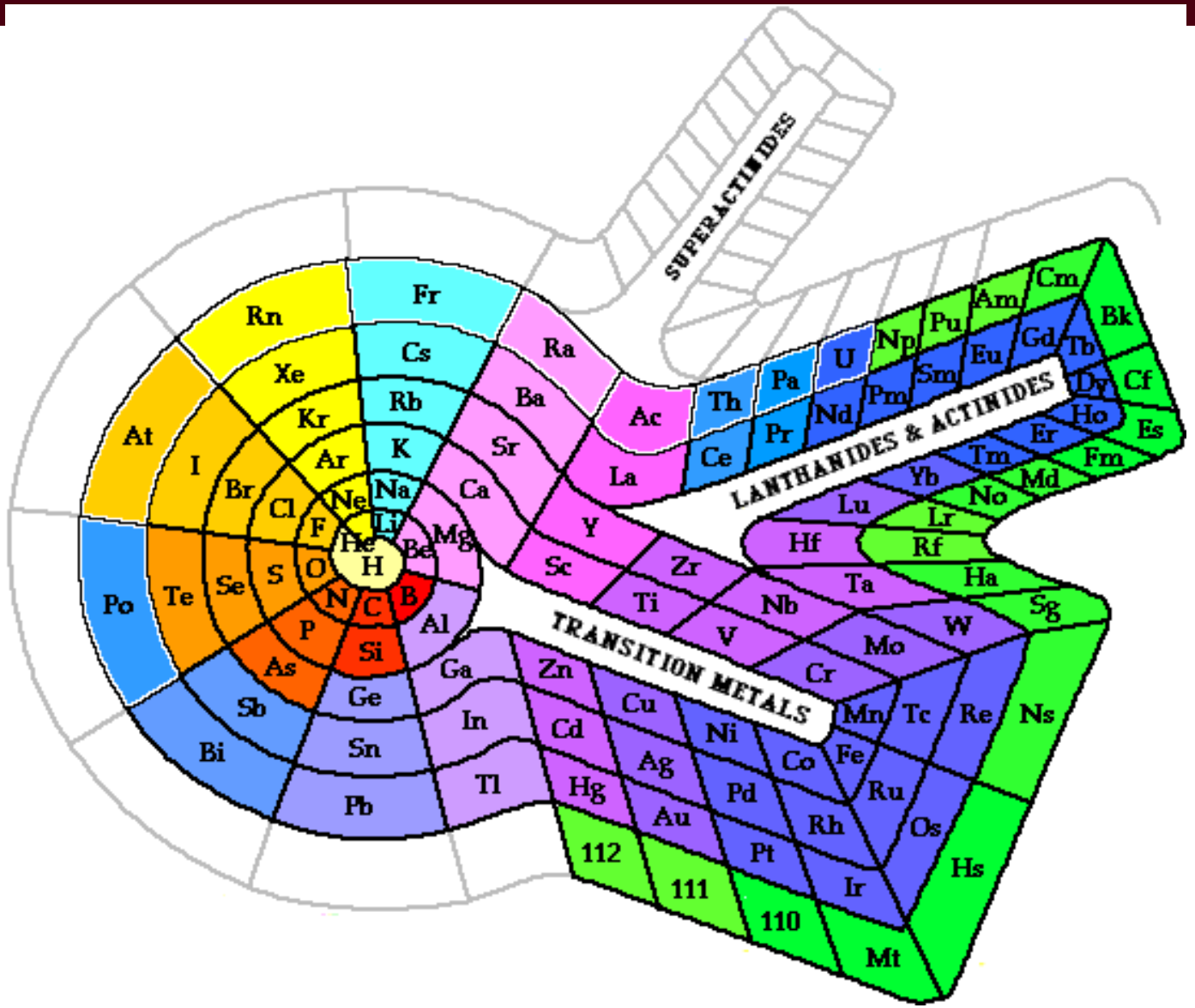
Is it a table?



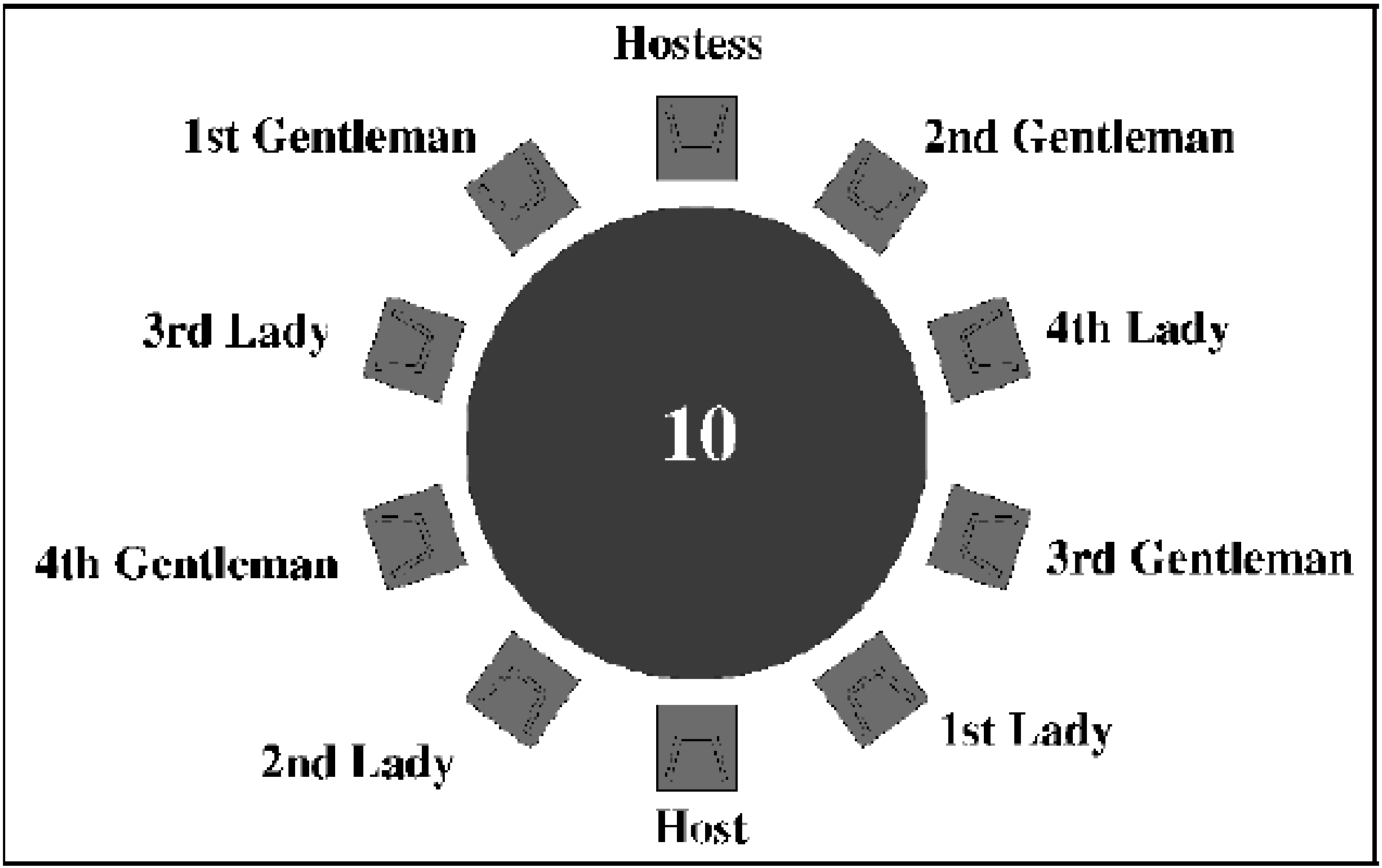
A wonderful table!



Still being improved



A table table



Thank	you	for
your	patience	!
Any	questions ?