Space-Time Adjustments to Transportation, Communication, and Information Technologies – Social Consequences and Policy Issues

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6 March 2002

Space Adjusting Technologies

transportation systems

communication systems

wireless communication

intelligent transportation systems

Location-based Services

Information Enhancement via

robotic systems

expert systems

smart cards

digital storage media

display technologies

voice recognition

image recognition systems

control systems

mobile wireless computing

. . . and more

Table 9.1. Spatial and temporal constraints on communication systems

		Spatial coincidence of communicating parties required	
		Yes	**No**
Temporal coincidence of communicating parties required	**Yes**	Face-to-face meeting **A**	Picture phone **B** Phone – (wire/cell/satellite) Teleconference (audio or audio-visual) Radio - CB/HAM/VHF Net phone Instant messaging Cuseeme
	No	Refrigerator notes **C** Hospital charts	Answering and recording machines **D** Mail/E-mail Telegrams, telex, fax Printed publications Computer conferencing

Source: Adapted from Janelle 1995

Table 1 Communication modes

	Synchronous	**Asynchronous**
Local	Requires transport Requires co-ordination Gives richness of communication (intense, personal) **Very high costs**	Requires transport Eliminates co-ordination Reduces costs
Distributed	Eliminates transport Requires co-ordination Requires additional modes in complex communication Reduces costs	Eliminates transport Eliminates co-ordination Is limited to particular communication **Very low costs**

Adapted by M. van Geenhuizen (2002) from Mitchell (1999)

Space-Time Transformations

Time-space Convergence

Time-space Compression

Human Space-time Extensibility

Trackability and LBS

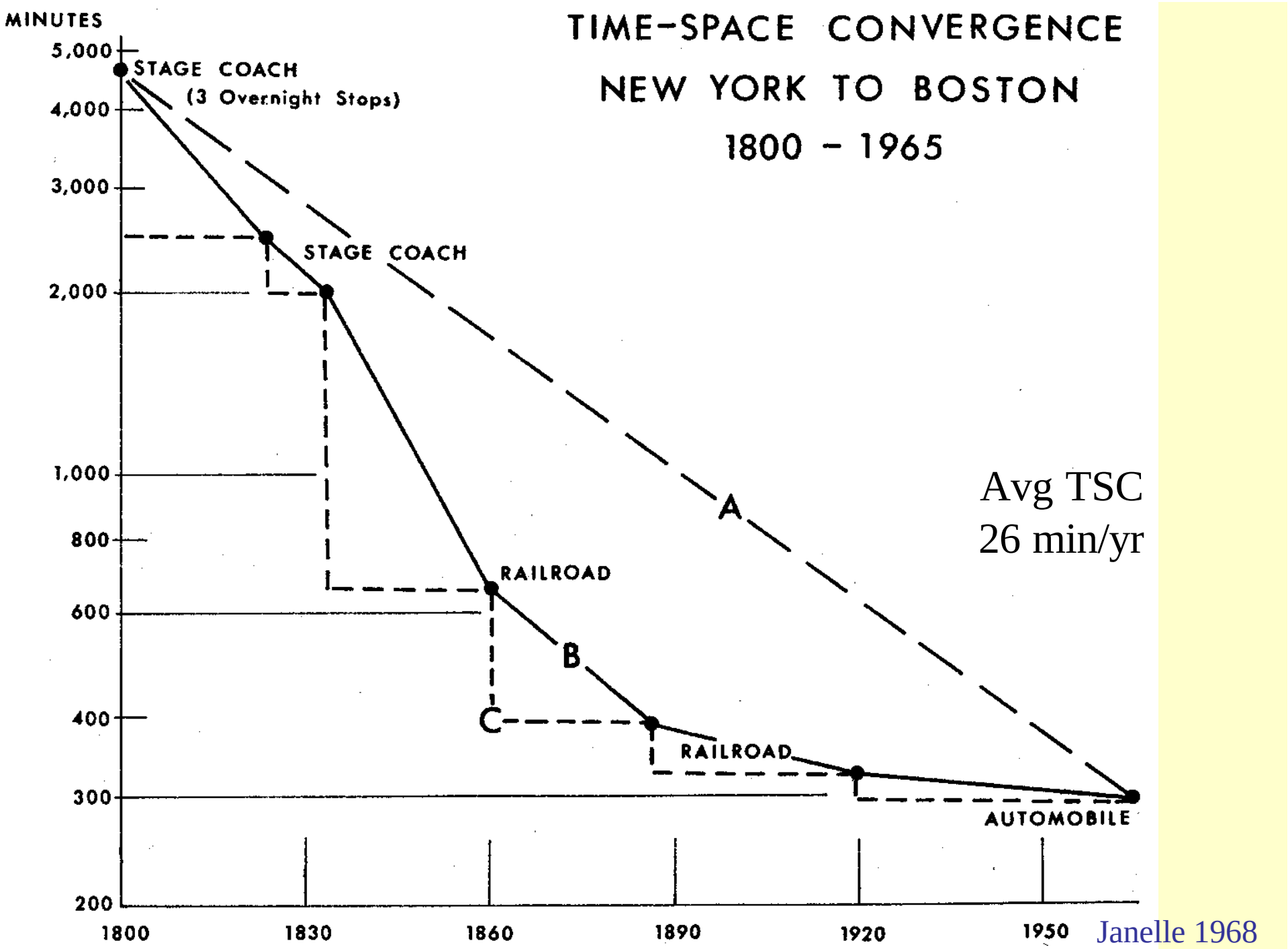
Los Angeles ⟺ Santa Barbara

500 minutes apart in 1901
100 minutes apart in 2001

Time-Space Convergence: 400 minutes
Average Rate of Convergence: 4 minutes per year
"velocity"

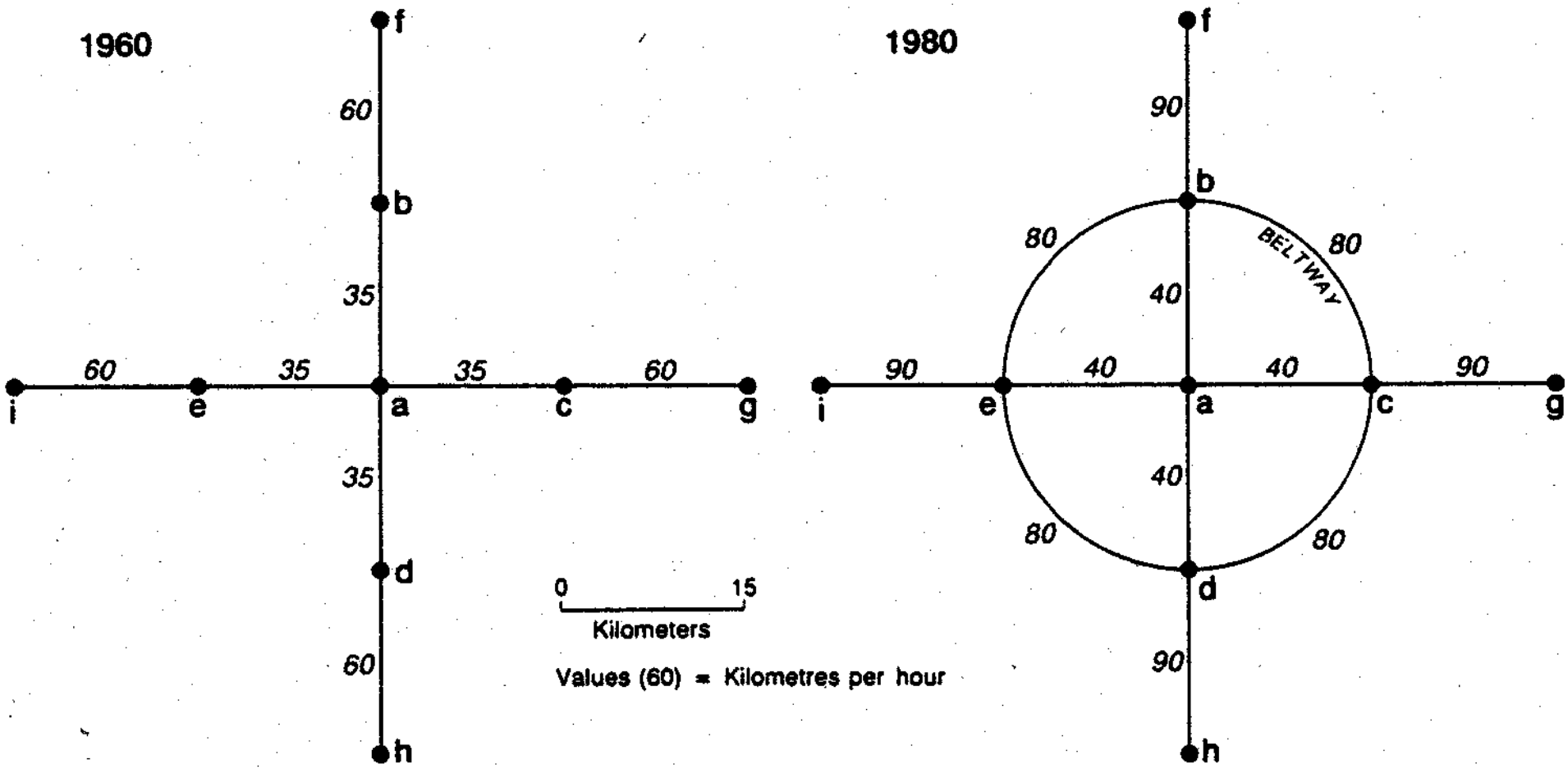
Problems of Travel Time as a Metric of Space:

- Variability in convergence and divergence among places
- Time-space inversions
- Asymmetric relationships between places
- Simultaneity of different convergence / divergence levels – by social class / transport mode


TIME-SPACE CONVERGENCE
NEW YORK TO BOSTON
1800 - 1965
MINUTES
5,000
4,000
3,000
2,000
1,000
800
600
400
300
200
STAGE COACH
(3 Overnight Stops)
STAGE COACH
RAILROAD
RAILROAD
AUTOMOBILE
A
B
C
1800
1830
1860
1890
1920
1950
Avg TSC
26 min/yr
Janelle 1968

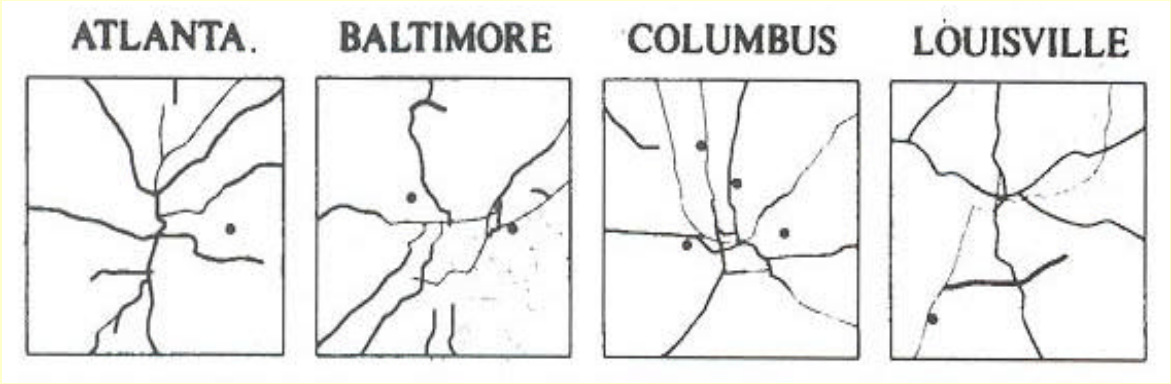
Time-Space Convergence
Metropolitan Expansion

- Morphologies of Cities
- Topologically Equivalent Locations
- TSC and Susceptible Land Supply
- Behavioral Responses to TSC – the Quest for Amenity

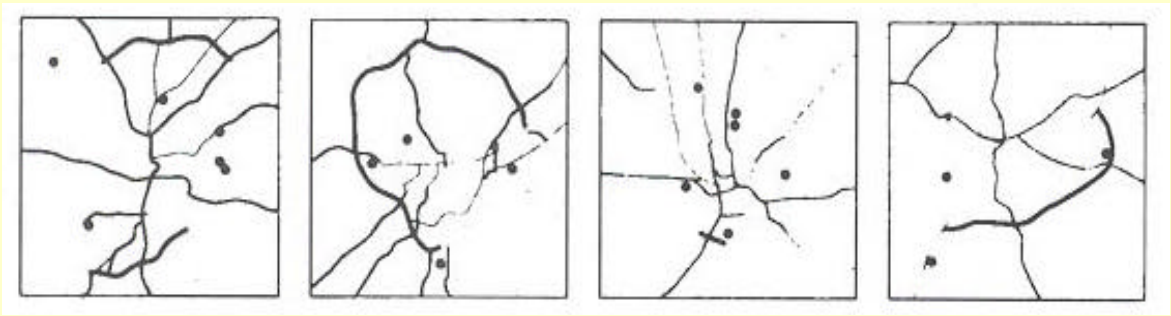


Janelle 1995

Pre 1957



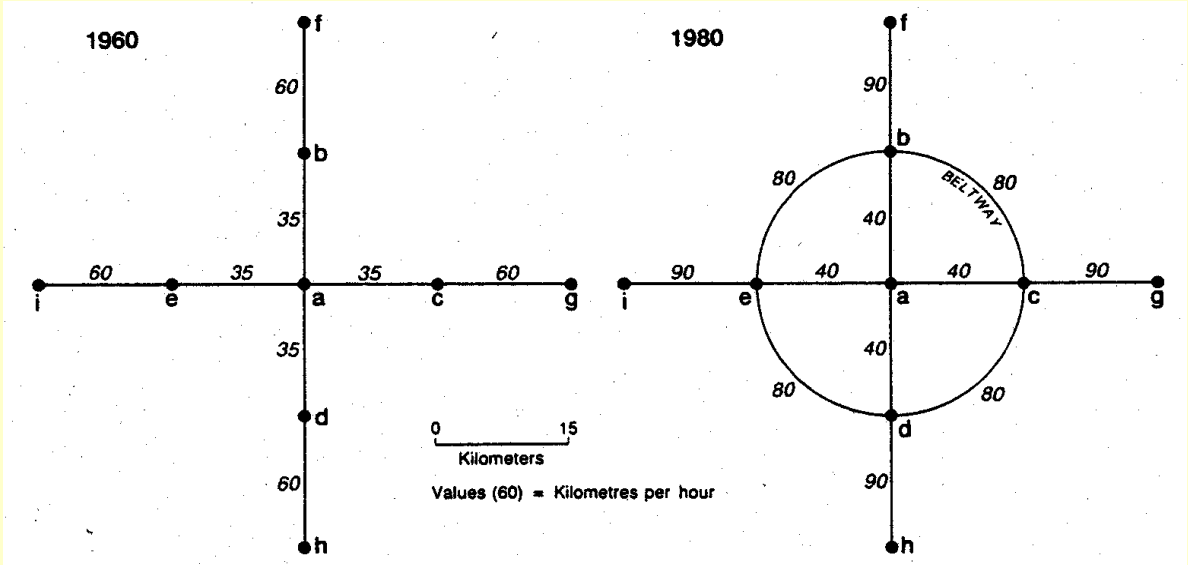
1961-1965



1976-1980

Convergence Rates for Metropolitan Settings

Topologically Equivalent Locations	**Average Travel Time (minutes)** each place to all 8 other places		**Convergence Rates 1960-1980** Average minutes per year, each place to all 8 other places using shortest time paths
	1960	**1980**	
City Center **- a**	33.2	27.5	**0.29**
b,c,d,e - Beltway	49.3	25.5	**1.19**
f,g,h,i - Ends	62.4	34.3	**1.4**

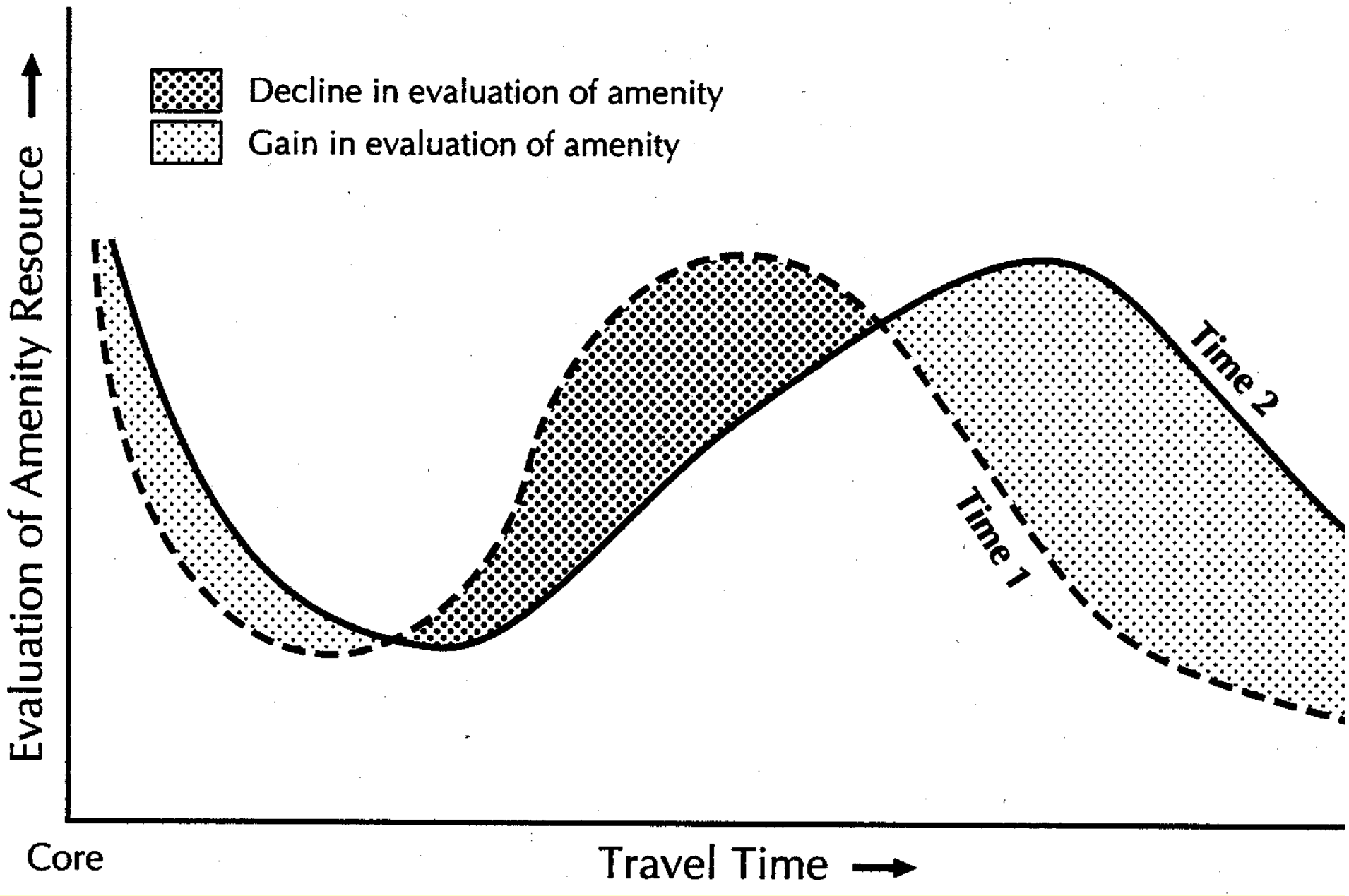


Janelle 1995

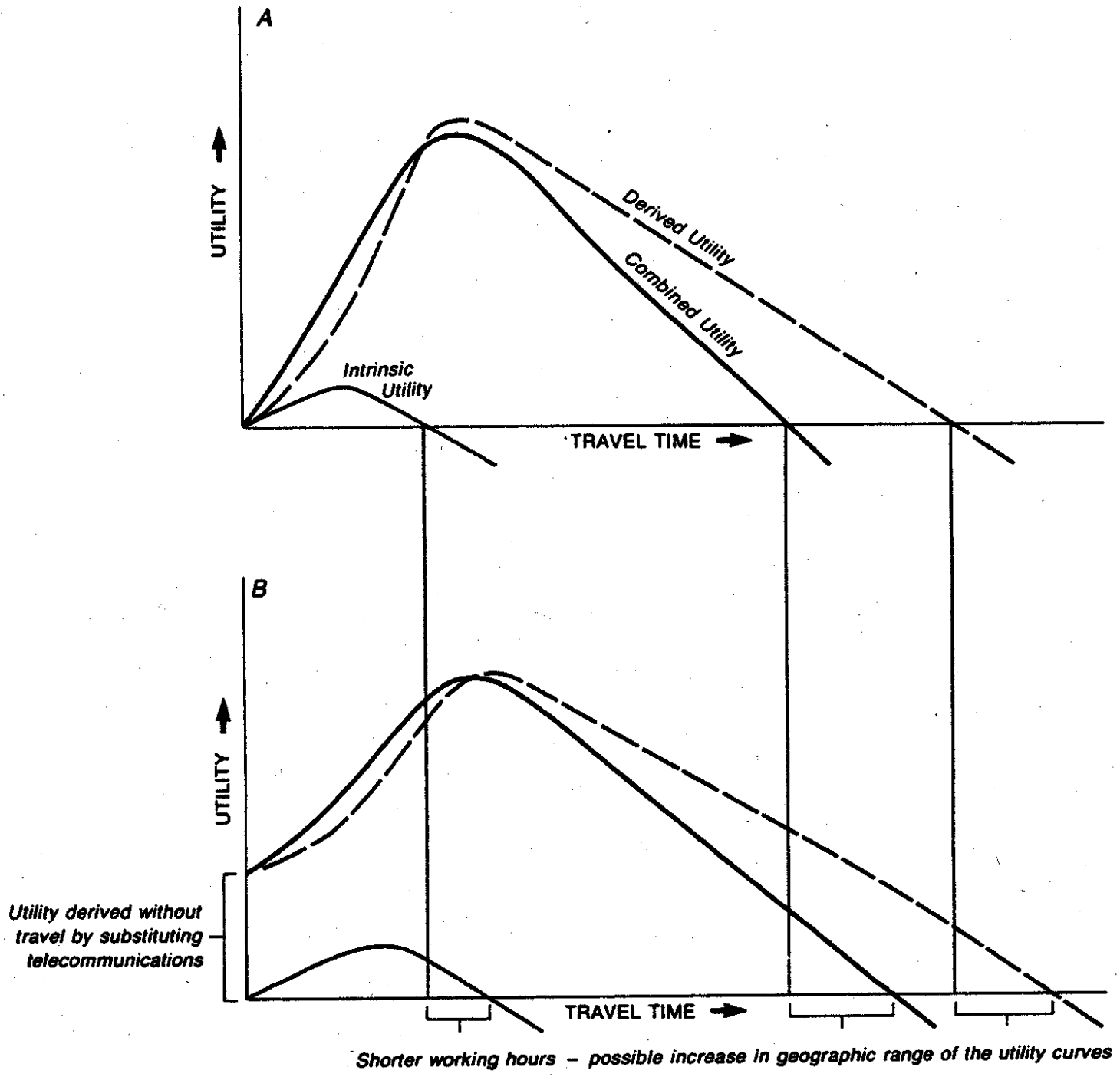
Travel Speeds and Accessible Land Resources from Urban Center

Average Travel Speed (Km/hr)	Average Daily Commuter Trip (1-way minutes)	Potential Distance from City Center (km)	Land Resource (Sq Km)
60	30	30	2827
70	30	35	3848
80	30	40	5027
80	50	67	14103

Janelle 1999



Janelle 1995



Adapted from
Guert Hupkes
1982

Janelle 1995

Time-space Compression

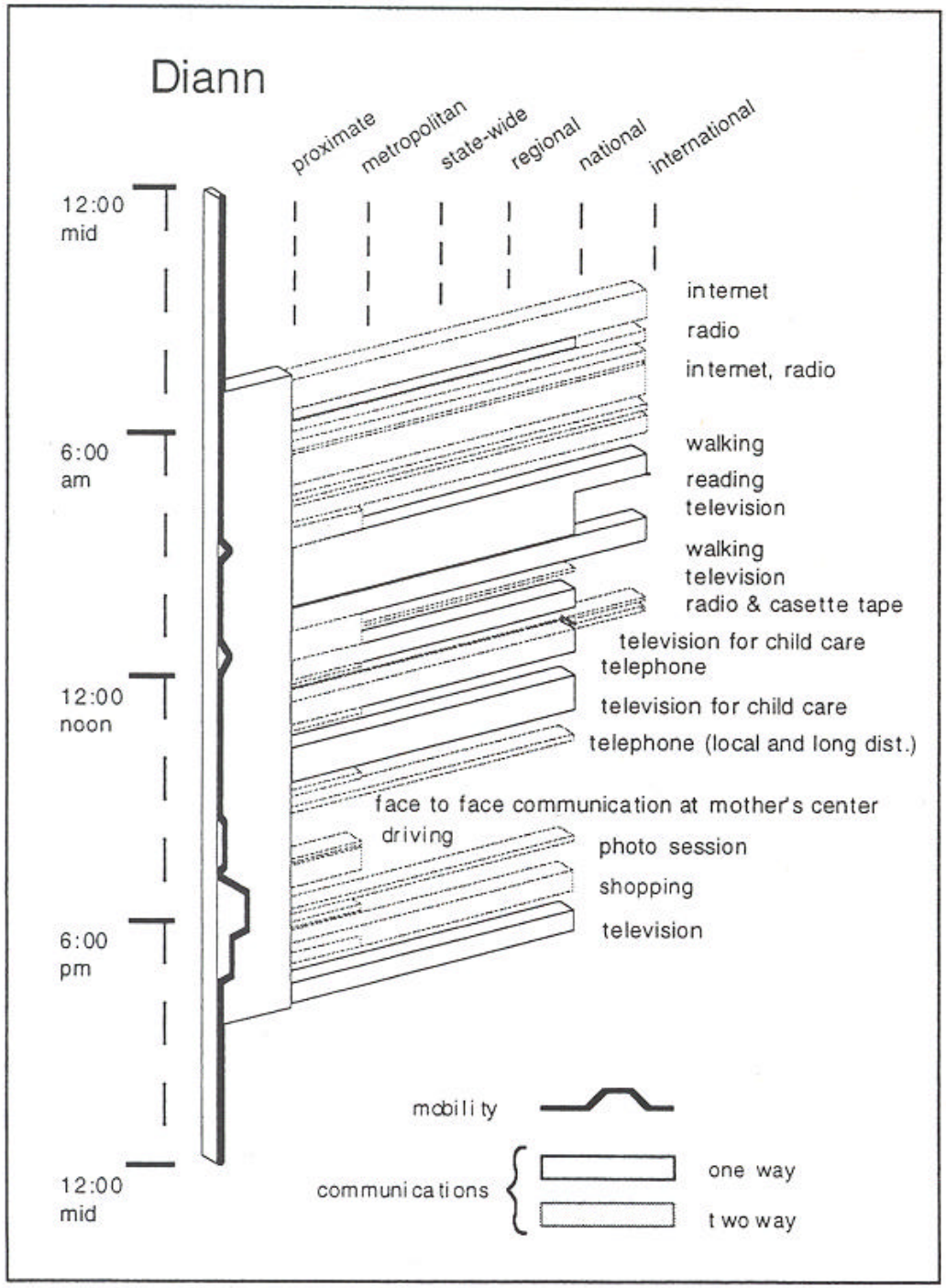
- David Harvey
  - 1989 *The Condition of Post Modernity*
  - 2001 *Spaces of Capital*
- Experiential – pace of life / escalation of events
- ‘Annihilation of space by time’ (Marx)
  - Links to capital accumulation process – speeding up production, exchange, circulation, consumption

Human Space-time Extensibility

- 'Measuring human extensibility in a shrinking world' (Janelle 1973)
  - The reciprocal of time-space convergence
  - Interaction beyond one's immediate physical presence
  - Projection of authority and of one's presence over space and time
- Parallels with Anthony Giddens' 'time-space distanciation' (1981, 1984)
  - Stretching social systems across space and time

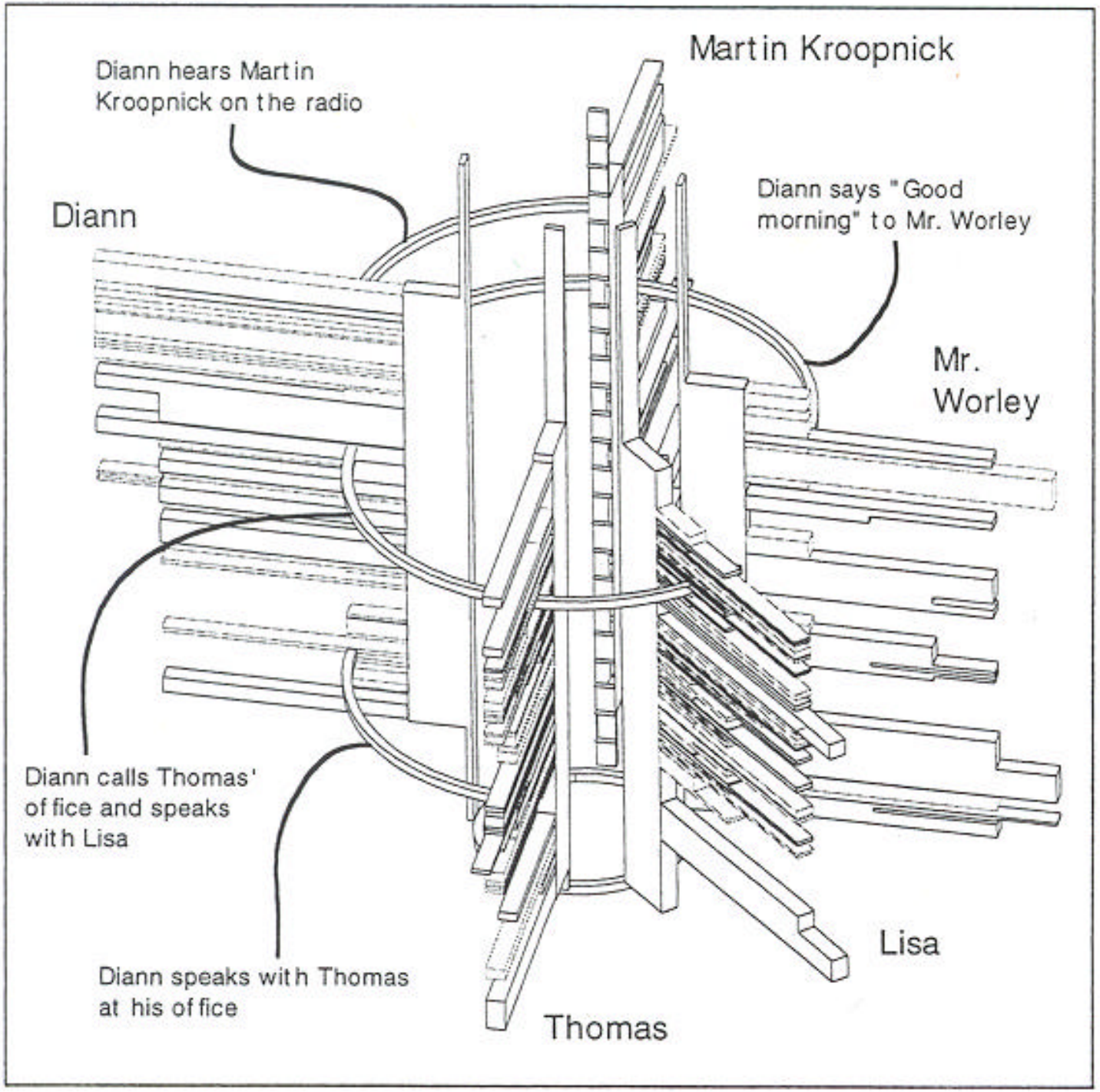
Recent Research Human Space-time Extensibility

- **Paul Adams** 'A reconsideration of personal boundaries in space-time' (1995); 'CAD-based accessibility model' (2000)
  - People as branching structures
  - The extensibility diagram
  - Linking micro and macro scales – the role of IT
  - Using CAD with data collected though personal interviews and detailed records of communication activities



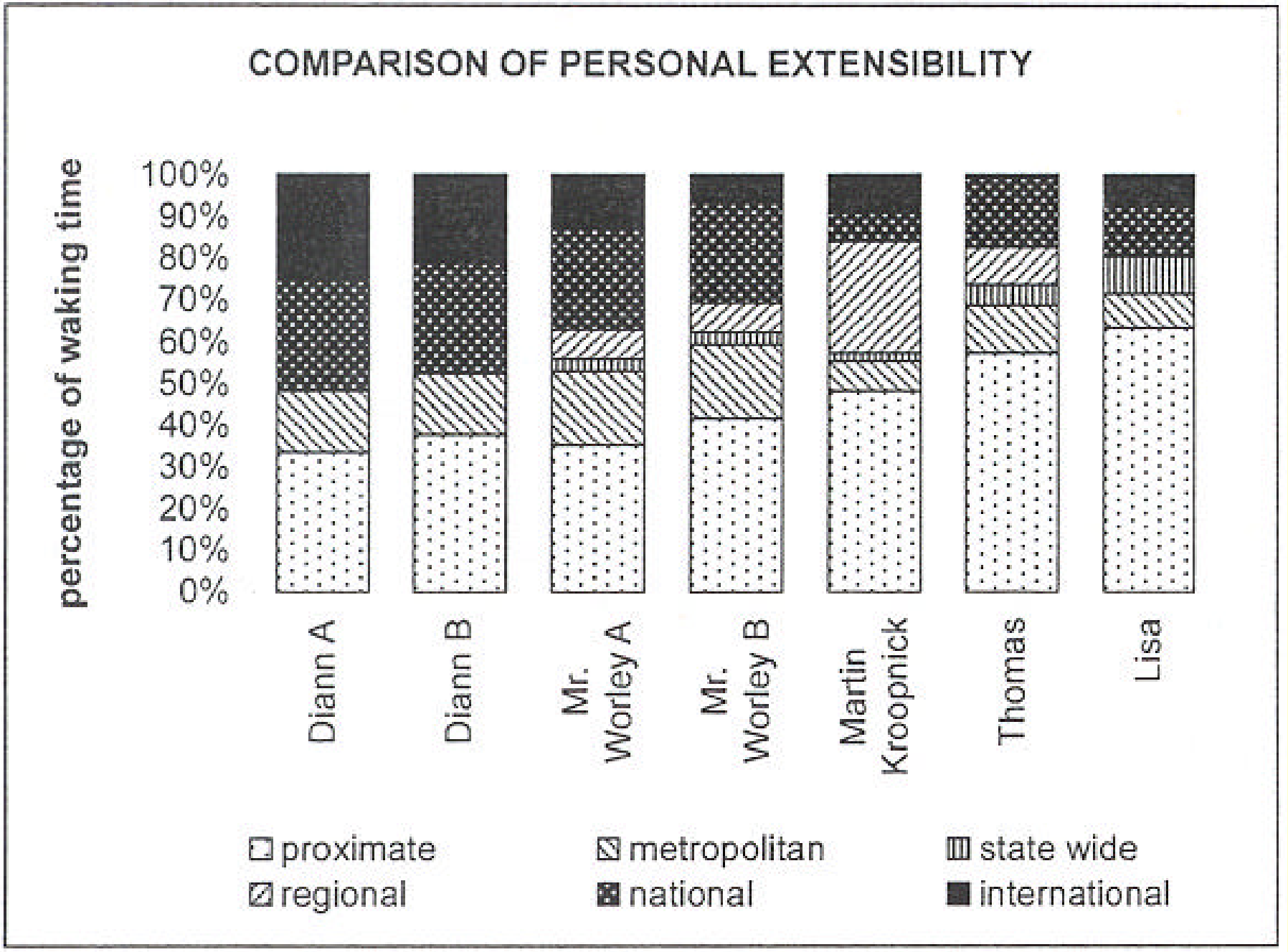
Diann's extensibility for a typical Thursday, autumn 1997

Paul Adams (2000)



Extensibility diagram linking Diann's communications with survey participants

Paul Adams (2000)

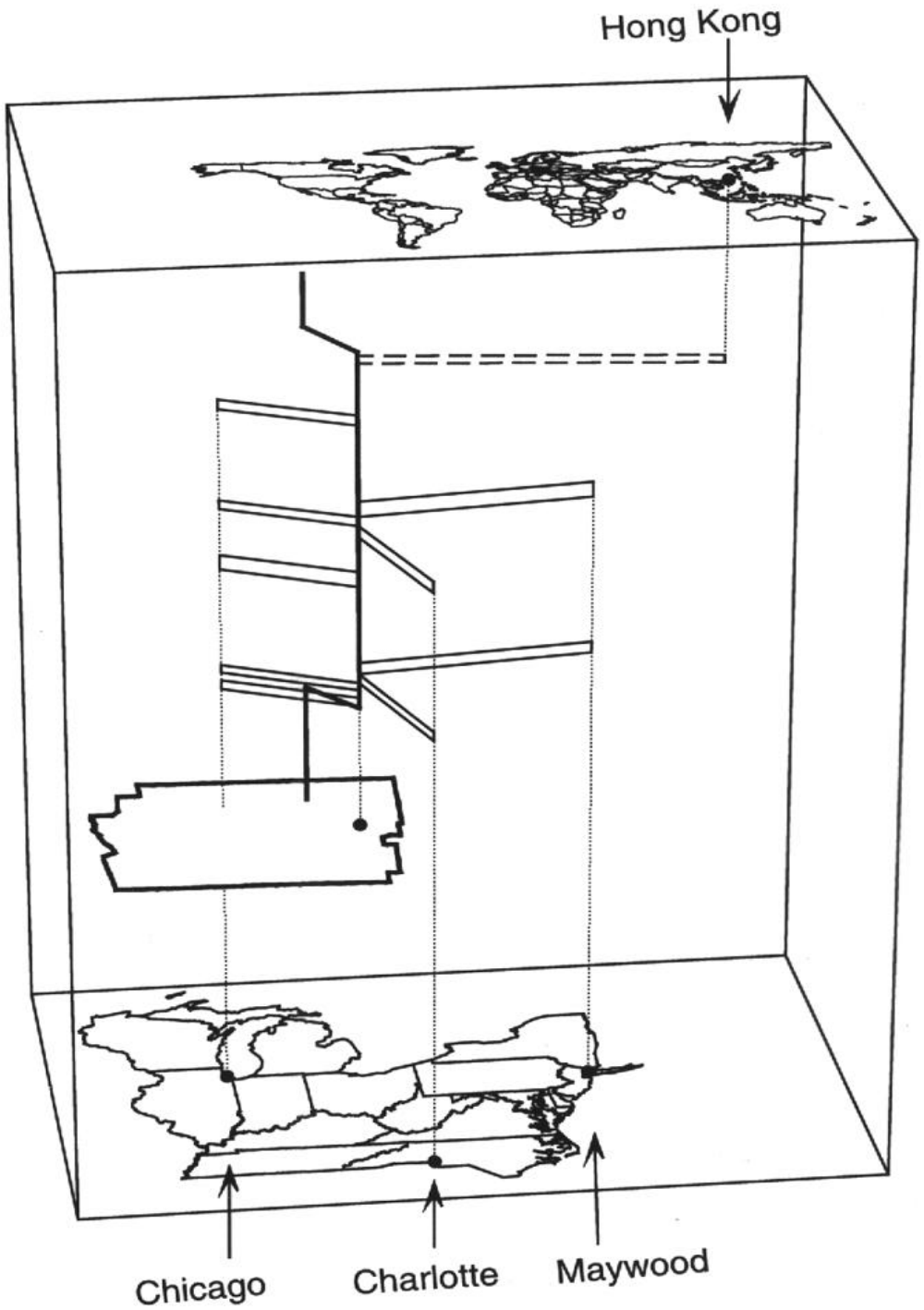


Paul Adams 1999, Bringing globalization home: A homeworker in the Information Age

Recent Research Human Space-time Extensibility

- **Mei-Po Kwan** 'Human extensibility and individual hybrid-accessibility' (2000)
  - Cartographic visualization of interaction in cyberspace ***and*** physical space
  - Extensibility diagram as analytic tool within 3D GIS using data from Web browser logs and personal interviews

Mei-Po Kwan 2000 ‘Human extensibility and individual hyprid-accessibility in space-time: A multiscale representation using GIS

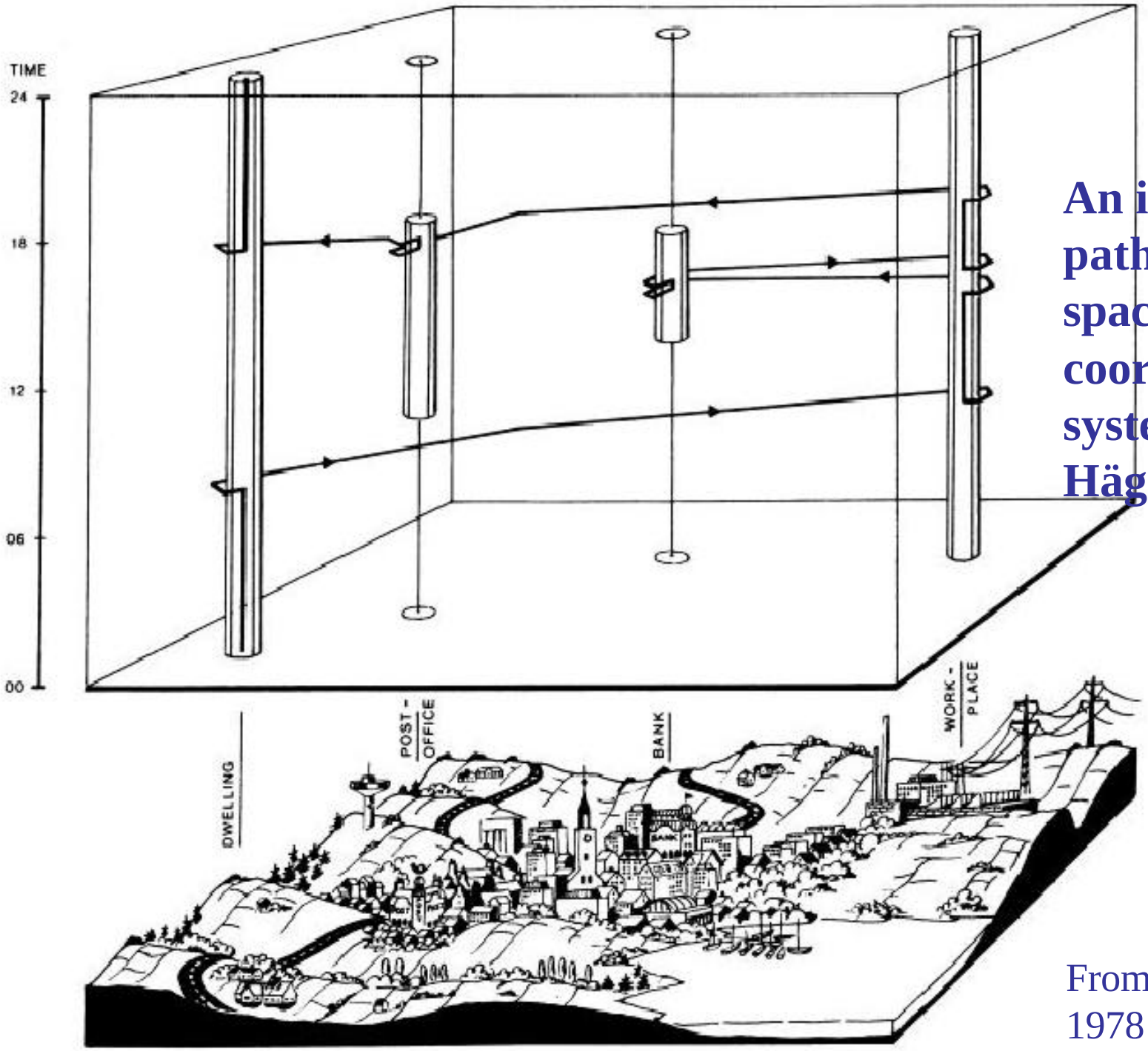


Multi-scale Extensibility diagram
3D GIS using data from Web browser logs and personal interviews

Mei-Po Kwan 2000

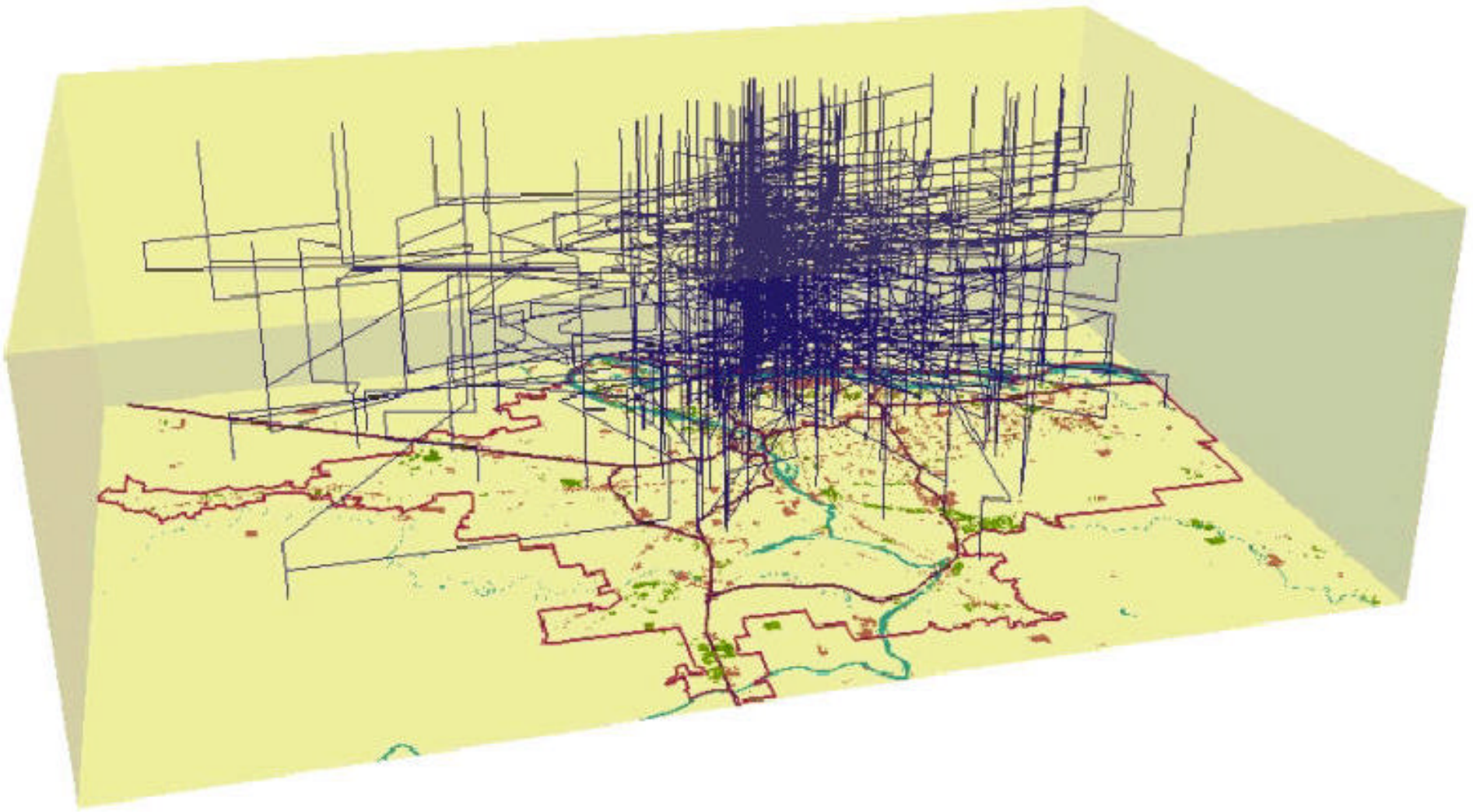
Trackability

- Consensual
  - Space-time activity diaries
  - Travel surveys
- Indirect surveillance
  - Zip code matching of Credit card expenditure patterns (M.J. Weiss, *The Clustering of America*; O.H. Gandy Jr. *The Panoptic Sort*)
- Direct real-time surveillance
  - Cameras, mobile phone, GPS, telemetry



An individual's path in time-space coordinate system -- after Hägerstrand

From B. Lenntorp 1978



Mei-Po Kwan, 2002 – GIS-base 3D geovisualization of space-time paths of African and Asian Americans. Data from Portland OR activity surveys

The Time Geography of a Canadian City Project

- DOMA (Dimensions of Metropolitan Activity) study of Halifax Canada

  Space-time budget surveys and analyses (Andrew Harvey 1971-72).
  - Approx 2100 one-day diaries spread over the week /
  - 99 activity types (Multinational Time Budget Study, Szalai 1972)
  - space-time coded to a resolution 1-minute in time and 100 meters in space
- Time Geography of a Canadian City Project (Janelle & Goodchild)
  - Reconstructing "census-like" data for any time of day
  - Factorial ecology based on activity data instead of census data (who is where when? What are they doing and with whom?)
    - PARAFAC 3-mode solution (activities, space, and time)
  - What is the link between individual behavior and urban ecological structure?

•Janelle & Goodchild, *Economic Geog* (1983), *Urban Geog* (1983)

•Goodchild & Janelle, *Environment & Planning A* (1984)

•Goodchild, Klinkenberg, & Janelle, *Geographical Analysis* (1993)

•Janelle, Klinkenberg, & Goodchild, *Geographical Systems* (1997)

Table 5. Selected average daily travel indicators for single-variable subpopulations[a].

Subpopulation	Maximum distance from home (km)	Speed for all trips (km h^{-1})	Total time for all trips (minutes)	Distance to usual shopping location (km)
Female	3.6* (3.5)	7.5* (9.3)	57.2* (47.7)	3.0 (2.5)
Male	4.6* (4.7)	9.6* (9.1)	81.5* (57.3)	2.9 (2.4)
Single	3.5* (3.7)	6.7* (7.8)	83.6* (65.6)	2.4* (2.0)
Married	4.4* (4.5)	9.2* (9.7)	62.8* (47.4)	3.1* (2.6)
No children	3.8* (3.7)	8.0** (8.3)	71.3* (59.0)	2.8* (2.1)
Children at home	4.5* (4.7)	8.9** (9.8)	65.9* (49.7)	3.1* (2.7)
Employed	4.2* (4.2)	9.4* (9.5)	76.9* (54.2)	2.9** (2.5)
Unemployed	2.7* (4.8)	6.4* (8.3)	51.2* (47.8)	3.1** (2.5)
Renters	3.7* (4.1)	7.6* (8.4)	67.1 (56.6)	2.6* (2.3)
Homeowners	4.7* (4.5)	9.5* (10.0)	69.3 (51.0)	3.3* (2.6)
Autos	4.4* (4.3)	9.3* (9.7)	68.4 (54.5)	3.1* (2.6)
No autos	3.0* (3.4)	5.8* (7.5)	64.7 (51.0)	2.2* (2.3)

Aggregating individual travel data by sub-populations

Space-time Correlations (Spearman) for Role Groups

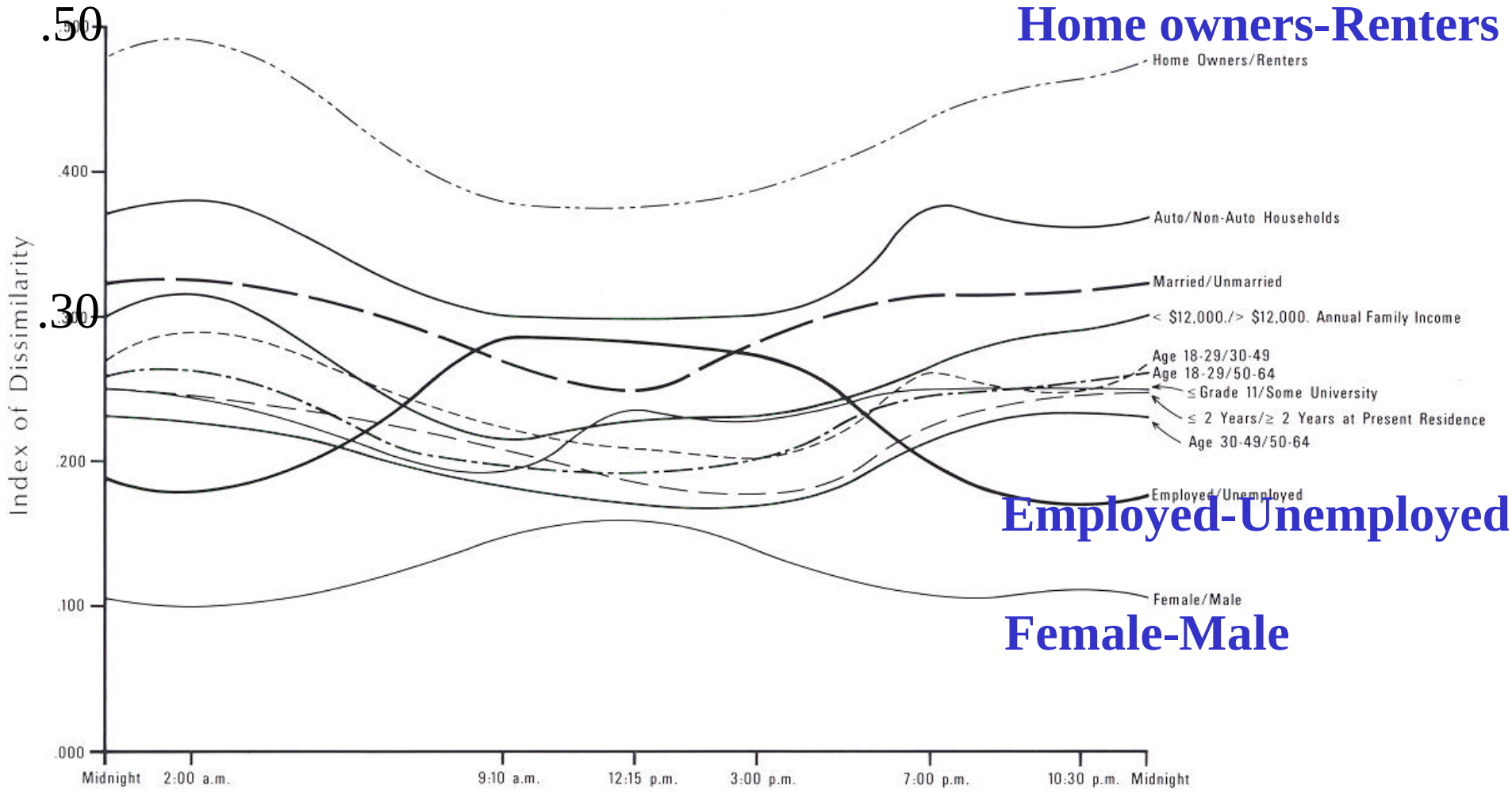
Time	FSNERA/MSNERA	FWCUOA/MWCEOA	FSNERA/FWCUOA
0100-0200	.50	.73	-.54
0800-0900	.33	.20	-.59
0900-1000	.17	-.14	-.68
1200-1300	.30	-.17	-.74
1400-1500	.44	-.22	-.63
1700-1800	.37	.27	-.65
1800-1900	.71	.44	-.60
2200-2300	.55	.66	-.75

based on number of activity episodes by role group in each of 29 regions in Halifax

Role-group correlations in space by time of day (for selected hours)

Diurnal Variations in the Spatial Correspondence of Subpopulations.

(Based on 32 Pseudo Census Tracts for Halifax-Dartmouth, Canada.)



Home owners-Renters

Employed-Unemployed

Female-Male

Figure 7

Index of Spatial Dissimilarity between subpopulations by time of day

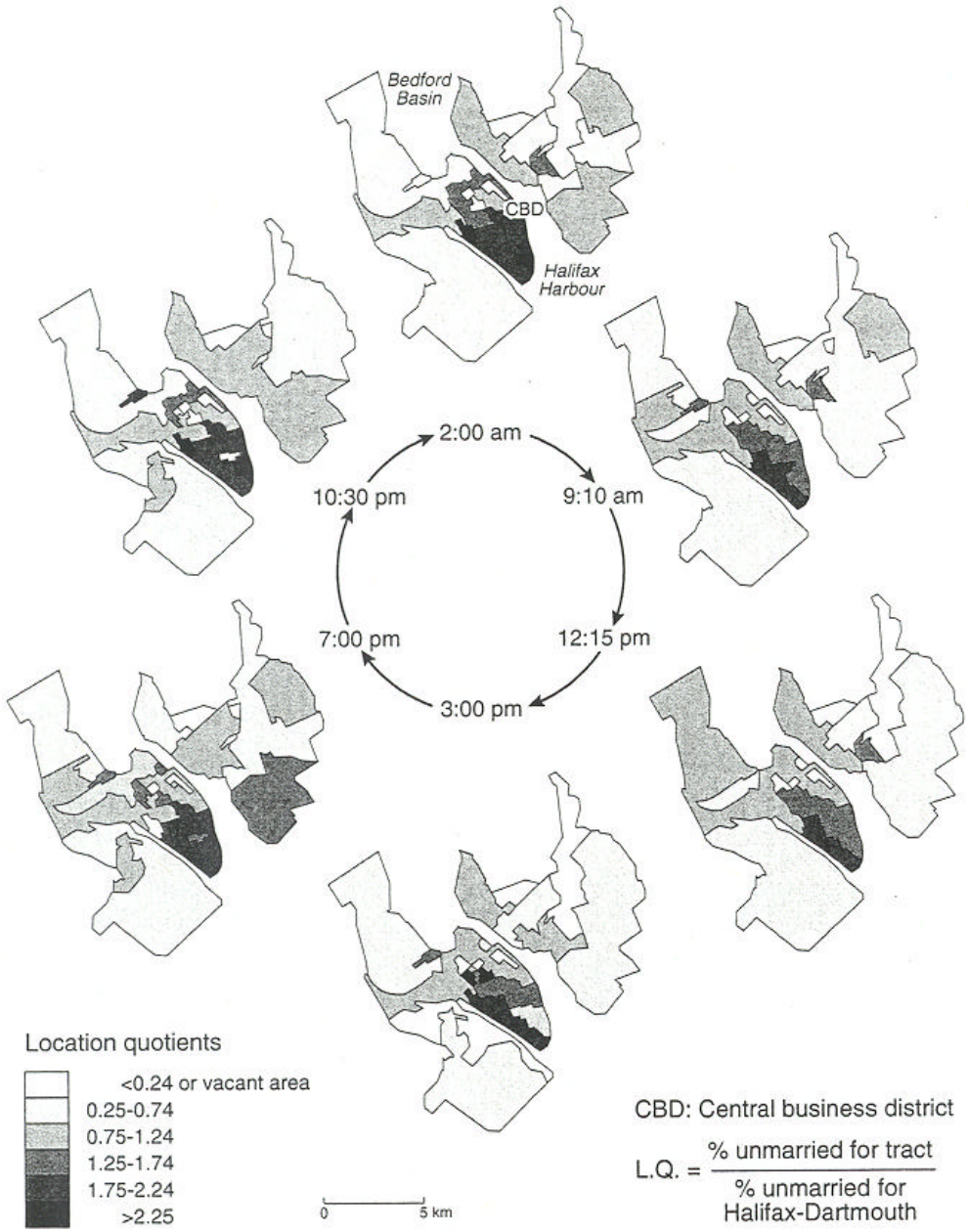
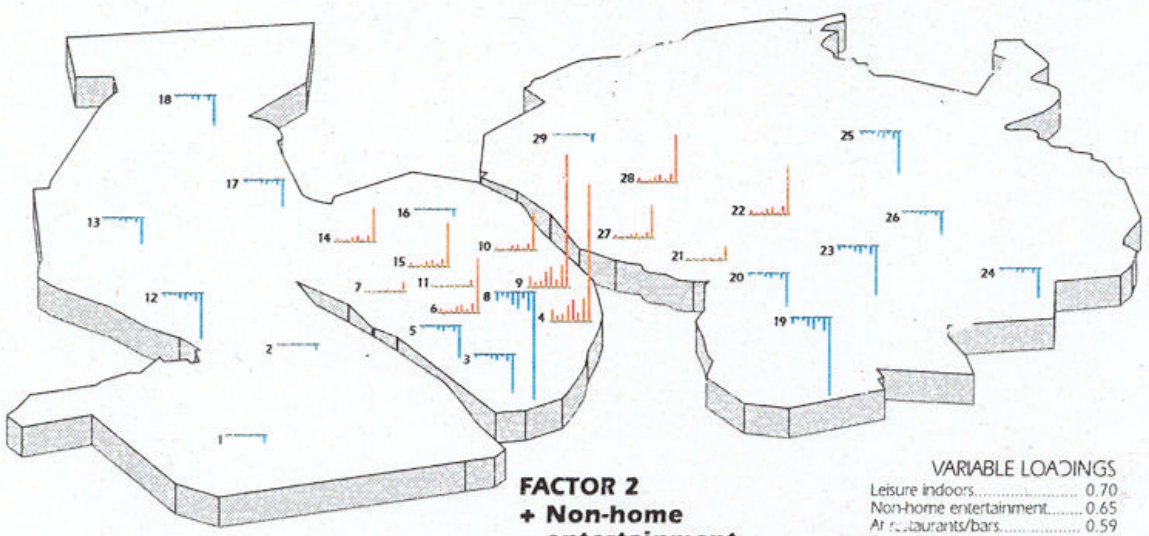
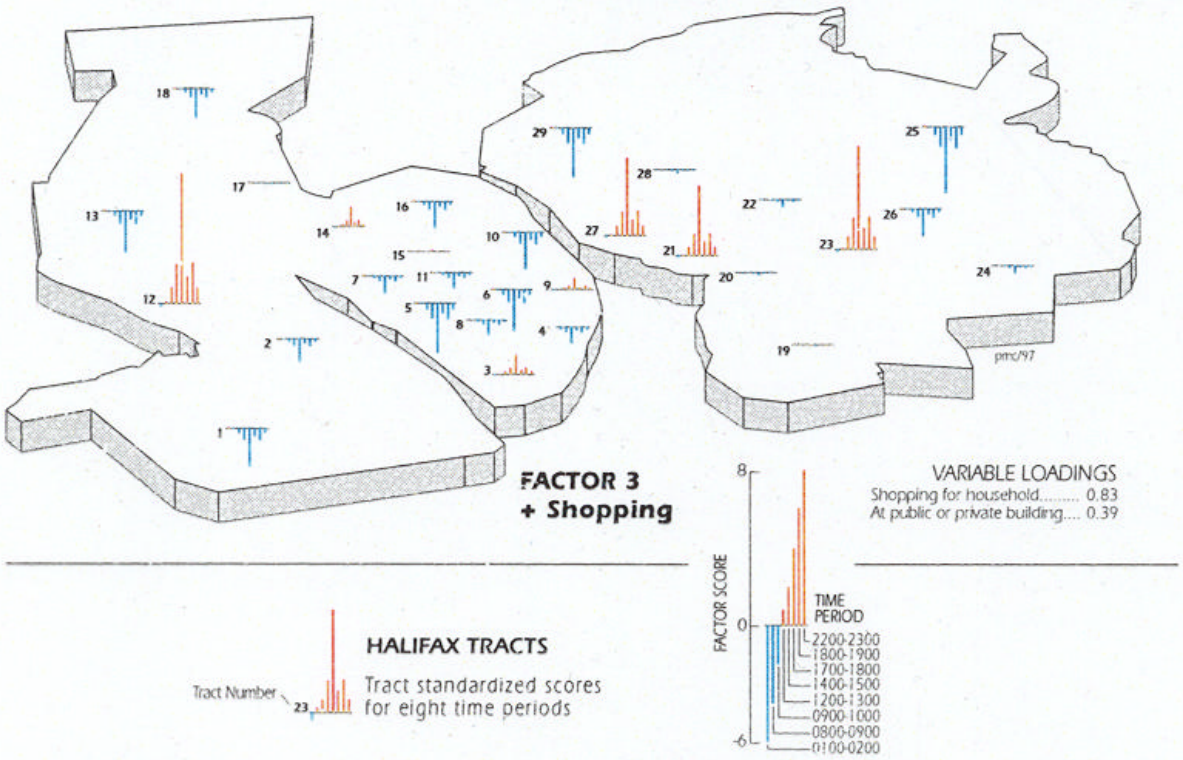


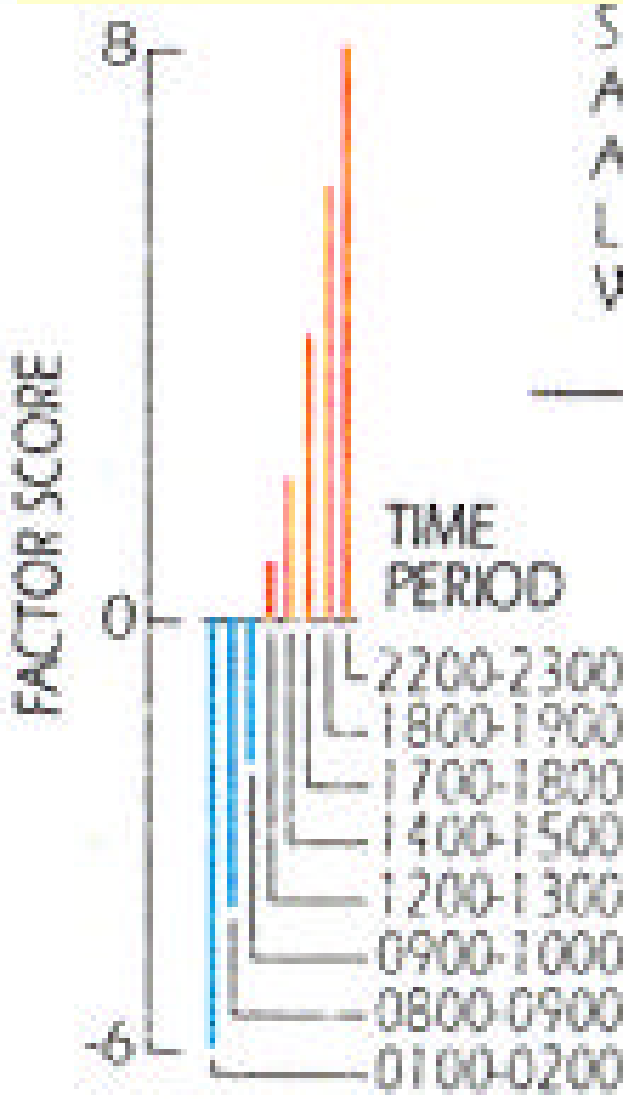
Figure 5.2
Diurnal variations in spatial concentration of unmarried respondents in Halifax-Dartmouth. Reproduced with permission from Janelle and Goodchild (1983: 412).

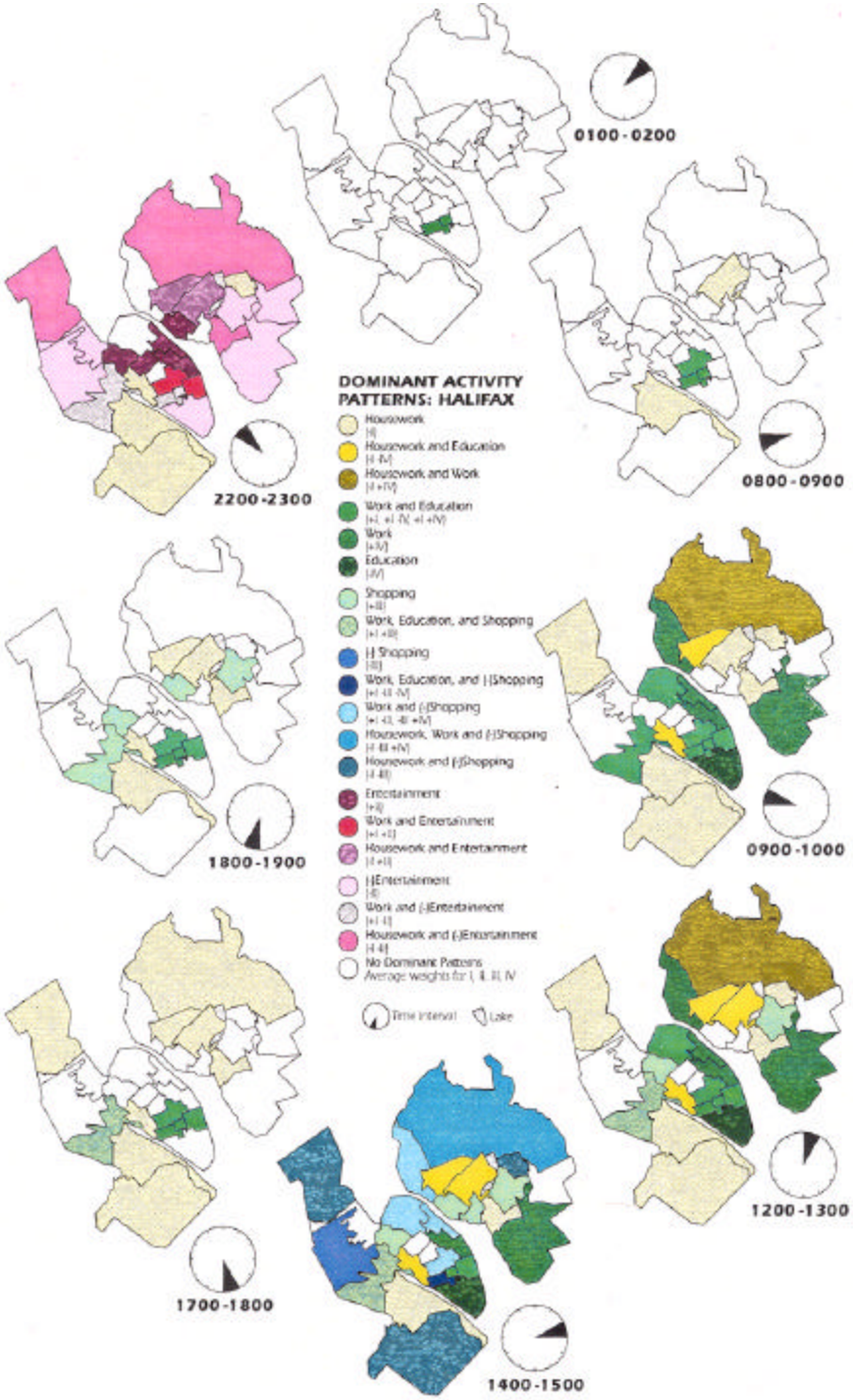
Location Quotients – Concentration of Unmarried Respondents by time of day

Space-time Ecology of Human Activity in Halifax







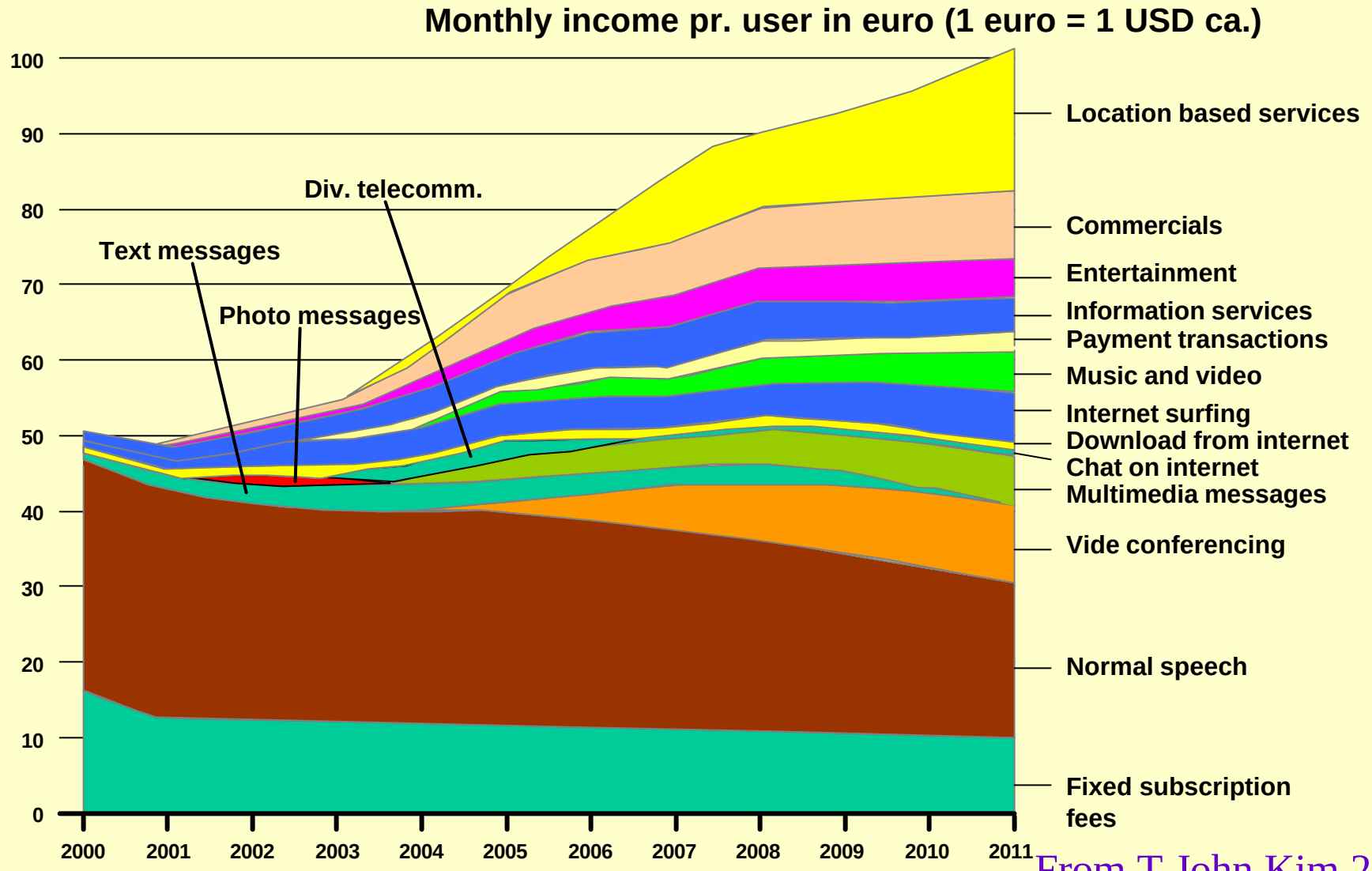


Dominant Activity Patterns By Time of Day

Location Based Services

- An LBS ". . . is an information service that exploits the ability of technology to know where it is, and to modify the information it presents accordingly" (MF Goodchild). [E.g., wireless GPS in real-time navigation]
- The Global Positioning System and cellular technologies enable new devices that know where they are, and are capable of modifying the information they collect and present based on that knowledge.
- The U.S. *Wireless Communication and Public Safety Act* (1999) permits operators of cellular networks to release geographic locations of users in emergency situations. [Tracking devices are now required in cell phones sold in the U.S.]
- New electronic services are being developed / offered to find locations, compute routes, identify nearby businesses and other facilities, notify of proximal events, report and find a stolen vehicle, Mayday alert, etc.

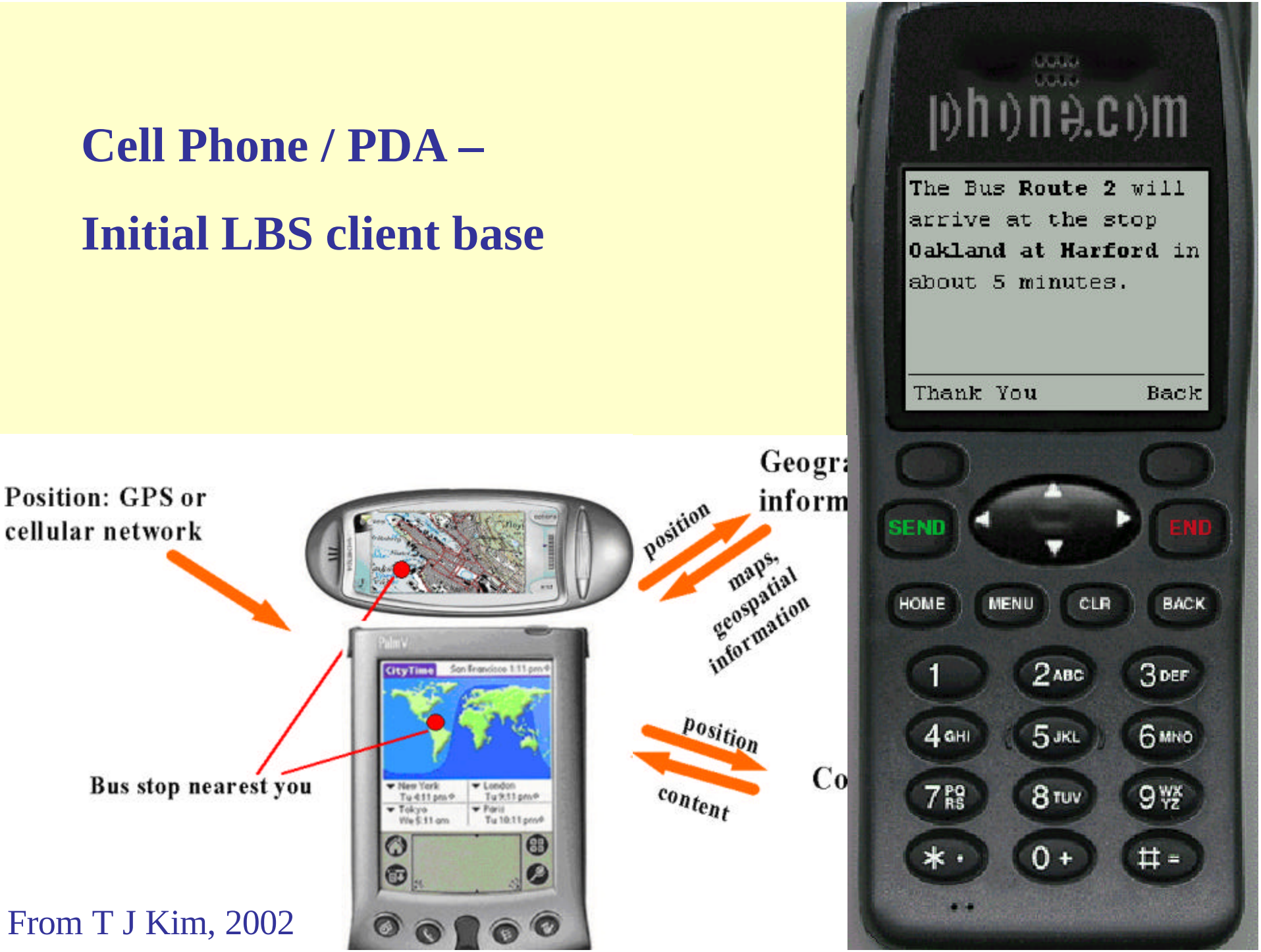
Nokia prognosis for 3G mobile communication



From T John Kim 2002

Cell Phone / PDA –

Initial LBS client base



From T J Kim, 2002

Location Service Concepts

- The Device
  - Cell phone
  - Palm top
  - Lap-top
  - Kiosk
  - Car-based computer
  - Cell antenna
  - Mobile device
  - Display
- Actors
- The Location
  - Point and Reference
  - Segmented Line
  - Address
  - Route
  - Descriptive Directions
  - Gazetteer
  - Direction
  - Polygon
- Payload Items
- The Service
  - Routing
  - Avoiding Traffic
  - Tourism
  - Regional Attractions
  - Event Handling
  - Maps and Backdrops
  - Guidance
  - Preference
- Service Providers

From T. John Kim, 2002

Issues Regarding LBS

- Use of LBS to support primary data capture in space and time -- by whom, for what purpose, and why?
- What new industries will emerge from LBS, and where? [E.g., new tools for visualization and analysis]
- What new forms of social / economic behavior are enabled? [Will surveillance uses undermine some current activity patterns or allow others?]
- What will be the implications of such behavior on regional development and on the social capital of places?
- Privacy, ethical, and security issues?
- Is this an instance of ‘radical technology’?

See www.csiss.org/events/meetings/location-based/

Social Science Research Challenges?

- Determine the extent to which mobility (the consumption of distance) is intrinsic to human society
- Conceptualize, measure, and model the social and cultural context of ICT and transport innovation -- e.g., accessibility, equity
- Document and interpret behavioral responses to new space-adjusting technologies
- Seek to understand how these behavioral responses impact on patterns and processes of regional and local space economies, equity, social cohesion, quality of life, and sustainable environments – and related structural changes in societies and economies
- Seek to understand how new technologies are socially constructed and embedded in the distribution of authority, power, and opportunity – e.g., what is LBS in terms of how it is socially constructed?
- Explore challenges arising to the dominant paradigms:
  - Questioning the Desirability of Mobility
  - Exploring possible benefits of space-time divergence, and space-time decompression
  - Providing personal autonomy over when and where to be tracked

Policy Issues and Measures

- Facilitating constructive uses of new information and communication technologies to enhance accessibility
- Protecting/respecting individual autonomy over personal information and behavior
- Protecting/respecting a minimum basic economic and cultural autonomy for places, regions, and nations
- Protecting vulnerable environments and populations from destructive uses of new technologies

References

- Paul Adams 1999, 'Bringing globalization home: A homeworker in the Information Age" *Urban Geography* 20:356-76
- Paul Adams 1995 'A reconsideration of personal boundaries in space-time' *Annals of the Association of American Geographers* 85: 267-85.
- Paul Adams "Application of a CAD-based accessibility model' In Janelle and Hodge (2000)
- MF Goodchild and DG Janelle, The City Around the Clock: Space-Time Patterns of Urban Ecological Structure *Environment and Planning, A* 16 (1984) 807-20.
- MF Goodchild and B Klinkenberg, and DG Janelle, A Factorial Model of Aggregate Spatio-Temporal Behavior: Application to the Diurnal Cycle, *Geographical Analysis* 5, (Oct 1993) 277-94.
- O.H. Gandy Jr. *The Panoptic Sort*
- David Harvey 1989 *The Condition of Post Modernity*
- David Harvey 2001 *Spaces of Capital*
- DG Janelle, Metropolitan Expansion, Telecommuting, and Transportation, in S Hanson, ed, *The Geography of Urban Transportation*, second edition (New York: Guilford Press, 1995) 407-34.
- DG Janelle, Urban Social Behavior in Time and Space, in LS. Bourne and D Ley, eds, *Social Geography of Canadian Cities* (McGill-Queens Press and the Canadian Association of Geographers, 1993) 103-18
- DG Janelle, Time Space Convergence and Urban Transportation Issues, in *Systems Thinking and the Quality of Life*. CK Blong, ed (Washington, DC: The Society for General Systems Research, 1975) 594-600.
- DG Janelle, Transportation Innovation and the Reinforcement of Urban Hierarchies, *High Speed Ground Transportation Journal* 8 (Fall 1974) 261-69.
- DG Janelle, Measuring Human Extensibility in a Shrinking World, *Journal of Geography* 72 (May 1973) 8-15.

References (cont.)

- DG Janelle, Spatial Reorganization: A Model and Concept, *Annals of the Association of American Geographers* 59 (June 1969) 348-64.
- DG Janelle, Central Place Development in a Time-Space Framework, *The Professional Geographer* 20 (Jan 1968) 5-10.
- DG Janelle, MF Goodchild, and B Klinkenberg, The Temporal Ordering of Urban Space and Daily Activity Patterns for Population Role Groups, *Geographical Systems* 5 (1998) 117-37.
- DG Janelle and MF Goodchild, Transportation Indicators of Space-Time Autonomy, *Urban Geography* 4 (Oct-Dec 1983) 317-37.
- DG Janelle and MF Goodchild, Diurnal Patterns of Social Group Distributions in a Canadian City, *Economic Geography* 59 (Oct 1983) 403-25.
- DG Janelle and D Hodge, editors, *Information, Place, and Cyberspace. Issues in Accessibility* (Berlin and Heidelberg: Springer-Verlag 2000, 382 pages.
- Mei-Po Kwan 2000 'Human extensibility and individual hyprid-accessibility in space-time: A multiscale representation using GIS, In Janelle and Hodge (2000)
- M.J. Weiss, *The Clustering of America*;