full system is made operational.6/ Here again the housing inventory will need to be tagged with respect to living qualities offered.

While these three locating variables represent bases of the household's location decision, in recognition of the imperfect knowledge of the household and the occasional decision based on whim, we anticipate that the Monte Carlo type of model we have been using will prove to offer an advantageous approach from an operational point of view. Thus, as in the present aggregative model, the attractiveness of various locations for various classes of households would be established based on the mix of the three location factors noted above, and then households would be distributed to locations on a probabilistic basis in a manner similar to our present aggregative residential model.

In summary, then, the conceptual elements identified in the first diagram above appear to fit into a systems approach to modeling household activities and residential development processes. This is not intended to be a well-honed statement of a conceptual system for housing and residential area analysis. Rather it is a rough-hewn framework for relating elements which must be recognized in an eventual statement of theory covering this aspect of urban processes.

B. Residential Location And Household Travel Behavior

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Residential activities consitute one of the primary space consuming uses to be found in the American city, and residential transactions make up the great bulk of activity in the urban land market. However, despite this seeming importance only a small proportion of the increasing level of attention being given to problems of urban areas is devoted to the process by which a household selects and finally obtains a residential site in the city. Admitedly, a number of studies are available dealing with the institutional aspects of the urban land market but these completely fail to illuminate the basic behavioral problem that is involved. Attempts at explaining the spatial structure of metropolitan areas have been prevelant for a number of decades but the current state of the arts does not represent any significant improvement upon the situation of a decade or two ago.

Most attempts to investigate the factors influencing the spatial structure of the city have tended to deal with rather gross aggregates. Residential land, for example, appears to be frequently regarded as an entity which is relatively homogeneous or which may be regarded as showing at best only a limited amount of internal differentiation. Recent empirical studies based upon data from the U.S. census have shown that while certain homogeneities exist, especially on an areal basis, the structure of residential land use is considerably more complex than has been postulated by many workers in the past. Perhaps an even more serious handicap to progress in this area has been the selection of improper units

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6/ For exploratory work in this direction see Wilson, Chapter 11, "Livability in the City: Attitudes and Urban Development," in Chapin and Weiss, Urban Growth Dynamics, (New York: John Wiley & Sons, Inc., 1962).

for study. Only recently has there risen a school of thought which views residential site selection as a result of a decision process based upon the individual household as a behavioral unit. Empirical studies have shown that households can indeed be classified into a number of relatively homogeneous groups with respect to characteristics such as stage of the family life cycle, income level, education level, etc. However, only a limited amount of work is available on the interaction between these factors and the selection of the household's residential site.

A factor which has been postulated as being of some major significance in the household's site selection process is the evaluation of the relative accesibility of various sites by the household. Accessibility is a term which is commonly encountered in the literature but which is, at present, without a sharp, commonly accepted definition. The accessibility of a residential site may be viewed as a complex index based upon the household's evaluation of a specific location vis-a-visa somewhat flexible set of other locations within the metropolitan region. This accessibility index is presumably influenced by the characteristics of the household, including the space preferences of the individuals who compose the household, and by the nature of the transportation environment of the region. Due to the extremely specialized nature of the space-economy and the resultant patterns of areal differentiation within the metropolitan region, the household is compelled to carry on a series of recurrent interactions with other specialized locations within the region. It seems reasonable to posit that the most realistic reflection of the household's view of accessibility is manifest in these daily movement patterns.

The last decade has seen a great upsurge of interest in the study of person movements within urban areas. Much of this interest has been based upon a very practical need for information on person movements for planning metropolitan transportation systems. Several different approaches have been evident within the last decade or two in this particular area. One of these, which had its practical expression as the origin-destination studies, relied upon a very simple picture of the movement pattern in which the characteristics of the individuals making the movements were almost completely ignored. The second approach, which came to its greatest development in the metropolitan transportation studies of the late 50's and early 60's, involved the examination of certain functional relationships wherein it was held that certain nearly invariant relationships existed between categories of land use and quantities of person trips. These studies attempted to project future land use patterns in the metropolitan area, associate specific trip generation rates with these posited patterns of land use, and then through a variety of algorithms (most of which were merely variations upon a rather simple theme, that of the so-called potential model) to assign these trip origins to specific destinations within the region. These trip assignment algorithms represent an implicit measure of what we have called accessibility. Since it fails to recognize any behavioral relation between the trip and the trip maker, it is a rather poor measure. A third approach to the study of household travel behavior has been developing within the last few years. This is basically a disaggregated, behavioral view of the situation which views the individual household as a decision making unit with regard to trip making behavior in the metropolitan region. Research in this area has tended to dicotomize household travel into two general areas, more for ease of investigation than for any other reason. These two areas are trip generation and trip structure. Trip generation studies attempt to relate the number and type of movements

originated by the household at the residential location to the characteristics of the household itself. A few of these studies have been guilty of rather serious statistical errors in attempting to impute areal characteristics to individual households. However a great deal of valuable work has been carried out in this particular topic. Trip structure studies, on the other hand, have to date taken the results of the trip generation work as more or less given. That is, it is assumed for the purposes of analysis that the household is engaged in making a trip and that the first purpose of the trip is known. The trip structure studies have defined a trip as a movement which begins and originates at the home base of the household, and they have investigated such topics as the number of stops in the trip, the functional composition of the stops, their spatial location with respect to the residential site, etc.

Research work at Northwestern on household travel behavior has covered both these general areas. An example of this is the work carried out by the Household Travel Behavior Study of the Department of Geography.* The study works mainly with historic data derived from a set of 30-day travel diaries collected to date. Research investigations carried out by this study have dealt with questions of gross trip generation by households, including differentiation by household class (based upon factor analysis of indices of socio-economic structure) and by major purpose, as well as by day of the week within these groups. Most of the attention of the study has been devoted to questions of trip structure in an attempt to examine the pattern of linkages that exist between various types of land use within the metropolitan region. Table I represents a linkage table based upon data for all households in the sample, covering movement between 14 different types of functions, each located within one of two regions in the city. Line 1, for instance, shows movements from residential locations in the area outside of the central business district to various functions both outside and inside the CBD. For example, 1,144 moves were made from residences outside the CBD to stores of the food and drug category at locations outside the central business district, whereas households in this location made only 170 moves to businesses of this type within the CBD. The trips that are included in this table cover all movements made by the members of sample households 10 years of age or older by all modes, including walking. An examination of the table at once reveals rather strong patterns of linkages between certain types of activities and very weak linkages between others. For instance, movements from establishments in the food-gas-drug category located outside the CBD are most strongly linked to stops at other stores in the same category and region and visits to other homeplaces in the same region. (This relation in turn depends upon the location of the establishment -- compare the preceding statement with line 2 in the lower portion of the table). Establishments in the clothing-department store category located within the CBD show a broad pattern of linkages with other types of establishments in the same region and quite weak linkages to establishments outside the CBD. The HTBS has devoted a considerable amount of attention to the development of simple stochastic models designed to assist in the analysis of these linkages. (See Marble 1964 and 1965).

TABLE 1

PERSON TRIPS, BY PURPOSE AND REGION, CEDAR RAPIDS, IOWA, 1949

To Outside Central Business District

From Outside Central Business District

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	0	1144	49	41	274	112	25	48	41	1204	525	1267	2202	749
2	1246	109	17	2	19	12	8	4	0	20	30	103	9	30
3	58	20	8	0	1	1	1	0	0	4	0	6	5	0
4	40	5	1	4	0	5	1	1	0	3	1	4	3	0
5	294	18	1	0	27	0	1	0	2	19	7	29	61	5
6	94	19	3	1	1	0	1	1	0	3	1	9	3	1
7	35	6	0	0	1	1	0	0	0	0	2	2	29	0
8	29	12	5	0	5	0	2	1	0	4	3	5	6	0
9	35	1	1	0	0	0	0	0	0	0	0	0	0	0
10	989	55	3	3	23	7	2	2	2	35	22	100	37	16
11	503	37	2	3	10	1	7	4	1	20	173	53	141	6
12	1263	94	2	4	37	3	5	2	0	76	66	170	17	12
13	1972	68	7	16	67	10	38	10	3	27	152	35	27	0
14	700	25	0	0	8	7	0	1	1	7	6	14	3	4

From Central Business District

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	0	5	0	1	4	1	1	0	3	4	4	10	81	0
2	132	37	4	0	5	1	2	0	0	1	2	30	9	0
3	60	22	10	0	6	1	1	4	0	6	8	15	14	0
4	7	2	0	0	0	0	0	1	0	0	1	1	0	0
5	94	15	0	1	10	1	2	1	0	8	12	39	57	1
6	6	1	1	1	0	0	0	0	0	2	0	4	2	0
7	9	7	0	1	0	4	4	0	0	0	3	0	13	0
8	8	6	0	0	1	0	0	0	1	3	2	2	9	.
9	11	3	0	0	1	1	0	1	0	5	1	2	0	.
10	80	5	0	0	7	2	0	1	2	8	7	20	56	0
11	34	4	1	0	1	0	1	1	0	3	33	13	16	1
12	95	1	0	0	0	0	0	0	0	1	1	5	0	0
13	211	46	0	4	2	0	3	1	0	56	1	11	2	0
14	2	0	0	0	0	0	0	0	0	1	0	0	0	0

KEY

Functions
1. Home, 2. Food, Gas and Drug, 3. Clothing, Department Store, and Variety,
4. Auto Sales and Repair, 5. Amusement and Other Retail, 6. Personal and Retail
Services, 7. Business - Financial, 8. Home Furnishing and Services, 9. Medical
and Other Professional, 10. Public Offices, etc., 11. Industry and Wholesale,
12. Visit other Homeplace, 13. Work, 14. School.

To Central Business District

1	2	3	4	5	6	7	8	9	10	11	12	13	14
0	170	232	19	248	29	49	44	85	205	90	12	536	0
133	6	9	0	3	0	1	3	2	12	4	0	5	0
88	2	2	0	1	0	0	0	0	2	1	0	0	0
16	2	0	0	0	0	0	1	0	1	0	0	2	0
189	3	2	0	11	0	0	0	0	3	5	0	1	0
16	1	4	0	5	0	2	0	4	2	1	0	1	0
14	0	5	0	1	1	1	3	0	6	0	1	1	0
24	2	2	0	1	0	0	0	0	0	0	0	1	0
41	0	6	0	1	0	0	1	0	1	0	0	0	0
112	26	9	1	9	2	1	1	2	5	20	0	60	0
61	12	12	1	5	0	3	1	2	6	26	0	1	0
15	14	8	0	35	1	4	2	3	8	7	0	3	0
414	19	21	1	57	2	31	6	6	34	12	3	25	0
1	0	7	0	0	2	0	1	1	0	0	0	26	0
1	20	52	3	55	4	12	13	14	13	3	0	37	0
151	45	59	3	50	6	4	6	4	17	3	0	33	0
123	115	390	5	56	10	15	38	16	25	14	3	31	0
12	3	5	1	0	0	0	2	0	1	0	0	1	0
113	83	43	2	63	4	12	10	2	7	2	3	48	0
15	4	13	0	9	5	0	2	1	2	1	0	1	0
7	14	33	5	19	2	3	4	5	7	0	0	12	0
15	10	37	4	11	1	8	6	3	7	2	0	3	0
15	20	32	2	7	4	5	1	3	9	4	1	2	0
33	31	39	1	16	2	3	7	4	17	5	0	72	0
9	9	25	0	7	1	0	2	2	0	10	0	20	0
5	1	1	0	6	0	0	0	2	1	2	2	1	0
62	16	27	1	126	5	9	5	5	50	10	1	2	0
0	1	6	0	1	0	0	0	0	0	1	0	0	0

Regions

> CBD - Central Business District, including contiguous wholesale and indus-
> trial Areas.
>
> Outside CBD - remainder of incorporated area including contiguous town of
> Marion, Iowa.

The main points to be made are that first, studies of residential site selection must be based upon the proper behavioral unit -- in this case the household, a good example here is the model posed by Herbert and Stevens (1960). Second, it seems logical to posit that accessibility is a significant factor in residential site selection decisions but that despite recent work on household travel behavior we are still a long way from being able to make firm statements about either its relative role in the site selection process or the manner in which households evaluate accessibility. An interesting area of investigation which might also serve to pull these two topics a bit closer together would be that of the manner in which a household in a new residential site gathers information and establishes an equilibrium set of movement patterns. Investigations in this area, as well as that of household to household varieties in the perception of space and distance relations, would enable future researchers to construct better models of the residential site selection process.

References

Herbert, John D. and Benjamin H. Stevens. (1960) "A Model for the Distribution of Residential Activity in Urban Areas," in Journal of Regional Science, Vol. 2, No. 2.

Marble, Duane F. (1964) Two Computer Programs for the Analysis of Simple Markov Chains. Regional Science Research Institute Discussion Paper No. 6.

_____ (1965) " A Simple Markovian Model of Trip Structures in a Metropolitan Region," Proceedings of the Regional Science Association, Wester Section Papers.

C. Residential Location Forecasting: Some Points on Perspective

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It is always easier to criticize other ideas and theories than to invent concepts. Moverover, giving advice on how to succeed beyond the admonition to do one's best and work hard is usually best practiced by those who are not active in the particular field of endeavor. Nevertheless, when one approaches the task of constructing a residential location model, there are many decisions to make before one begins programming. I will comment briefly on three of these important questions.

For What purpose is the model being assembled?

Will the output of the model be used for estimating future travel demand and hence in the design of new transportation facilities? Perhaps the model will keep tract of the structural condition of dwellings and be operated to provide estimates of housing construction and the fiscal split between renewal, rehabilitation, and public and private construction. The model may incorporate racial-ethnic factors and be used to anticipate potential future conflict in the demand for housing.

To the extent that we fully understand man's behavior with respect to location, we might consider a generalized residential location model that provides answers to these questions and almost any others one might ask. But such an