Chapter 4
Finding Housing Genotypes by Graph Theory: An Investigation into Malay Houses

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Abstract Finding cultural characteristics of housing has been a subject in many disciplines. Most of their approaches, however, were qualitative rather than quantitative since even those houses with a similar style exhibit a wide variety of morphological solutions with varying shapes and sizes. As a result, researchers tended to focus on materials, decorations and layouts that are relatively easy to analyse. In recent decades, many attempts have been made to quantify built environment. Space syntax and shape grammar are two representative theories that radically systemised this approach. They highlighted, however, only one side of the reality; space syntax on spatial configuration and shape grammar on formal composition; thus could not suggest the holistic understanding of it. To overcome this limit, this research suggests a new graph representation where the information of both form and space are retained. What is the cultural DNA of Malay houses? We often try to relate this kind of question to traditional houses, but DNA is something that transcends time by transferring itself from an old generation to a new. To find this persisting genotypical element, modern apartment floor plans were converted to the new graph representation and then analysed to filter out the most common spatial elements in them. Through the interpretation of these commonalities, culture-specific properties from the past were revealed.

4.1 Transformation of Malay House

The traditional houses in Malaysia can be defined as a timber-framed structure on stilts that has evolved to adapt to the tropical climate [1]. To keep the structure undamaged from dampness and floor, houses were elevated from the ground using piles. In the hot and humid climate, this raised position also helps ventilation for human comfort as it allows air flow under it. The space underneath is also used for

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storage or for breeding livestock. In fact, this elevated dwelling form can be defined as the most generic architectural feature throughout the South-East Asia. Before going up to the main floor via a staircase, people leave their shoes on the stone slab below, and wash their feet. At the top of the staircase, there begins a sequence of spaces, from the public male area to the private female area. The *anjung* and *serambi* are public spaces; the former is the covered porch where residents rest or chat with visitors, and the latter is the reception area for male guests. Next, the *ruma ibu* is the main private area of the house; here family members do all kinds of everyday activities including praying and sleeping. Passing through the passage-way, or *selang*, one reaches the back portion of the house, the *rumah dapur* where women gather and cook. From this female area, one goes out to the back yard. Simply put, the whole domestic configuration can be categorised into three zones, i.e. formal reception, private living, and female cooking (Fig. 4.1).

What is remarkable here is that the functional spaces are arranged in a sequential manner without partitions. Hence, each functional space is experienced by the change in space volume or floor levels [2]. It can be said that the spatial organisation of the interior is based on an 'open sequence' from the front porch to the back kitchen. It is obvious that open plans enables unobstructed ventilation, but it may also reflect Malay people's preference for open space over partitioned space due to their collectivistic life style in their domestic living [3].

Malaysia experienced fast urbanisation and was ranked fourth (72.8 %) in urban population rate in Asia in 2012 survey [4]. Due to a radical increase in housing demand and scarcity in usable land inside major cities, apartment housing has

Fig. 4.1 Traditional Malay house (*Photo* by the author)

Fig. 4.2 Typical apartment block plan in Malaysia

become an unavoidable choice of dwelling type in the market. The proportion of apartment housing in Malaysia is 19.9 % but it goes up to 66.6 % in Kuala Lumpur which has 1.4 million population in a 243 km^2 area [5]. In the typical middle class apartment block plan, units are connected on each side of the central corridor (Fig. 4.2). To maximize ventilation, it normally has void spaces between the corridor and unit plans which is called 'air-wells' and external facades also have deep cut-outs or indents between units to provide maximum exposure to the open air. These unique void spaces enable a wide range of variations in Malaysian apartment configuration. There are two radically different formal characteristics in apartment housing when compared to traditional Malay houses. First, it has a restricted condition in spatial layout due to its packing and stacking method in construction. For example, a unit plan in the middle of the block has to face party walls on each side and can only provide a single entrance open to the corridor side. Second, in contrast to the simple open sequence of domestic space in traditional houses, modern apartment units have many separate functional rooms with partitions as seen in Fig. 4.2.

4.2 A Graph-Theoretic Method to Find Culture-Specific Characteristics

In the discipline of architecture, the dualism of form and space dichotomy has prevailed for a long time. Recently, this division has been more articulated by more refined theories, the space syntax theory [6] and shape grammars [7]. The former effectively captures spatial relations by means of graph theoretical methods, but strips out shapes and sizes that are essential for formal description. Conversely, the latter focuses on the definition of complete form while relegates spatial

connectedness to a minor significance. In both, an effort to highlight one dimension inevitably sacrifices the other with no effort to bridge them. In a typical design environment, space and form interacts constantly from the beginning to the end. Hence, as Boast describes, spatial and formal measures "cannot be defined without reference to the other and they are, therefore, separable only in analysis and not in practice" [8]. Typically, modern collective housing has a bigger volume of building block that encloses individual dwellings and this enforces higher-level geometric constraint to the planning of units. In this context, to distill the cultural traits of housing design, in terms of spatial configuration, it is crucial to count in the higher-level geometric conditions of building block. In Tabor's definition, when a unit plan is designed within the constraints of boundary geometry, it is called 'permutational approach' in contrast to 'additive approach' where the unit can grow or change its form without any friction with the boundary [9]. March and Steadman explored the way where an empty rectangular plan is filled in by rooms based on 'adjacency requirements'. Unlike other graph representations such as a justified graph in space syntax theory where only the relation between rooms are focused, they suggested a graph that corresponds to the four compass directions of the surrounding exterior space as in Fig. 4.3 [10]. Inspired by Steadman's idea, Seo suggested another type of more 'easy to read' representation that suites to the analysis of modern multi-unit housing in Seoul (Fig. 4.4) [11].

This graph can represent the spatial connectedness between rooms by highlighting access and adjacency relations while preserving the boundary shape of individual units. Those four corner rooms in the grey zone are vertices of rectangular interior zone that excludes balconies. By using this representation, it becomes possible to analyse the syntactic configuration of domestic space in close relation with the building structure. When it is applied to the typical Malaysian apartment plan, however, some problems arise. As can be identified in Fig. 4.2, with some void spaces around each unit, Malaysian plans cannot be represented by normal

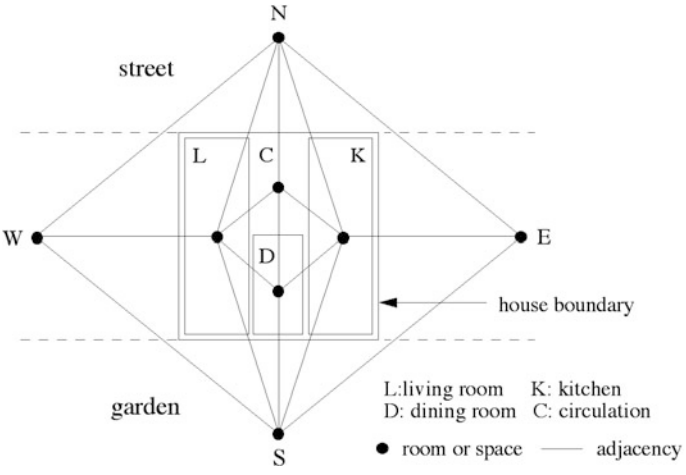

Fig. 4.3 Graph representation for the unit of English terrace houses [10]

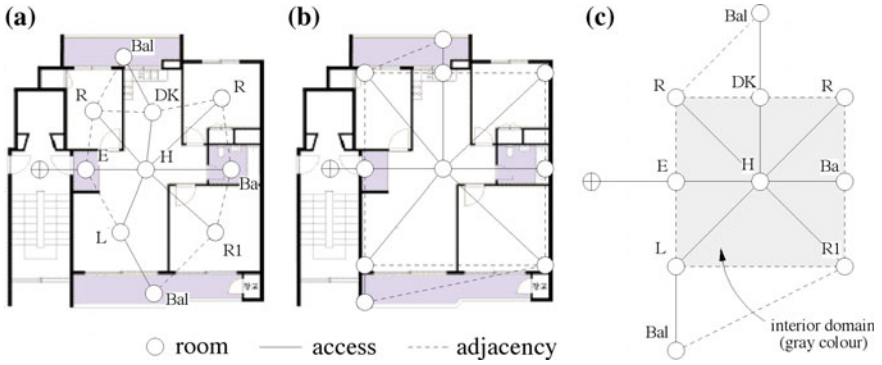

Fig. 4.4 Typical apartment unit plan in Seoul and its graph representation [11]

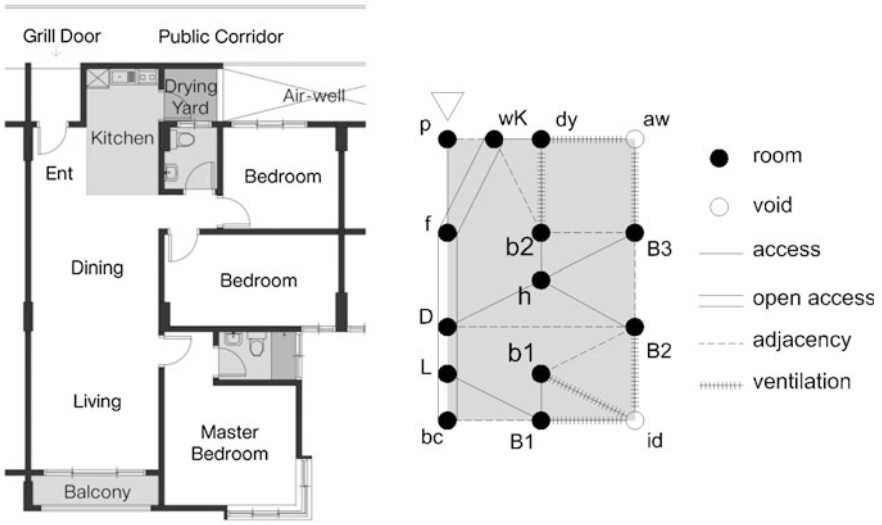

Fig. 4.5 Typical apartment unit plan in Malaysia and its graph representation (*p* porch, *f* foyer, *dy* drying yard, *aw* air-well, *id* indents, *b* bathroom, *h* hall, *bc* balcony, *B* bedroom, *L* living room, *D* dining room; numbers attached to room labels are to count the same functional spaces)

rectangular boxes. To solve this problem, a concept of 'dummy cells' is used to represent voids such as air-wells or cut-outs in the façade (Fig. 4.5).

In the figure, black dots represent rooms and unfilled dots voids—thus dummy cells. Now there are four different connections between rooms: access, open access, adjacency and ventilation, each with a different line type. 'Open access' with the symbol of double lines indicates that two rooms are connected without door, or with the minimum width of the size of two doors, i.e. approximately 1.8 m. It is to show how actively two rooms are making a close link to facilitate the internal circulation of

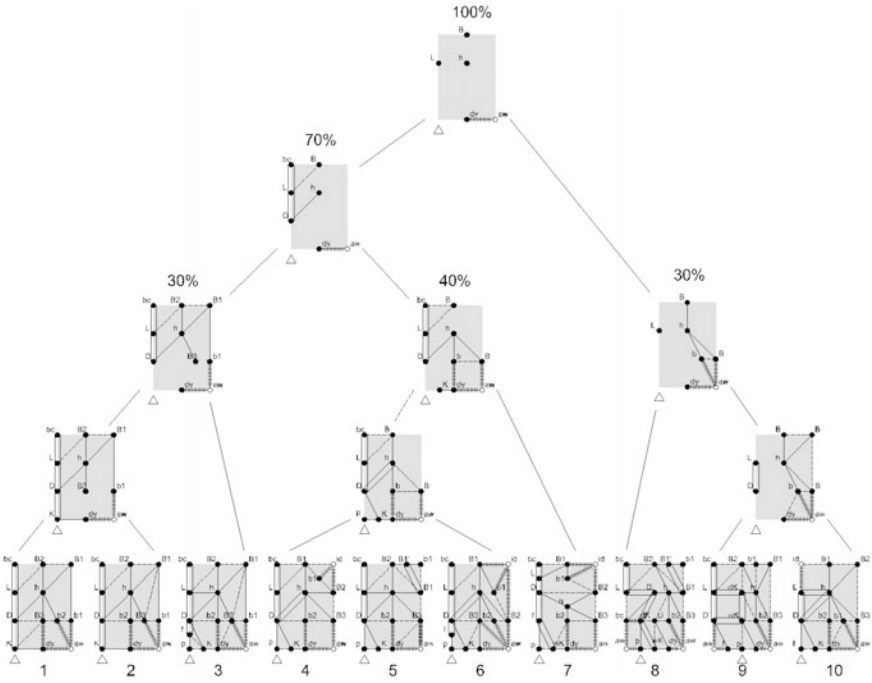

Fig. 4.6 Bottom-up process of finding common spatial elements within the original plan graphs

movements. 'Ventilation' with the symbol of railway indicates the connection between a room and a void space; it is always the connection to either air-wells (aw) or indents (id) on facades. Compared to the previous graph in Fig. 4.4, this graph includes more detailed information of the plan. Now, using this more refined graph technique, a methematical analysis of a multiple number of plans is possible. By sorting out common sub-graphs from the whole sample of plans, it is possible to filter out the culture-specific elements in the modern houses. From the property website in Malaysia, we collected apartment plans in Kuala Lumpur that have three bedrooms and positioned in the middle of block plans to give them an equal condition. As it was difficult to collect floor plans directly from developers or local authority, we tried to identify as many plans from Malaysian property websites that are 3 bedroom mid-block units. Converting 35 plans that satisfy this condition to graphs, it was revealed that these all geometrically different plans can be categorised into 10 different graphs. Then these 10 graphs were analysed by the suggested process of finding common denominators (Fig. 4.6). Put simple, it is a bottom-up process of generating sub-graphs that are shared by a multiple number of original graphs. By stripping off some nodes and lines, 10 original graphs are gradually merge into the upper sub-graphs, and finally arrive at the single most common sub-set at the top of the graph tree. Unlike other graph representations such as the justified graph in space syntax, our method allows individual room cells remain in isolation from others in the sub-graph;

it is because the boundary rectangular box (hatched dark) still keeps the information of their locality within the plan even after they lose their connections to other rooms. The graph on the top can be regarded as universal, so marked with 100 %. In this graph, it is identified that one of three bedrooms is always on the outside periphery of the plan and the living is always on the party wall side on which the entrance is also located. At the bottom of the plan, on the public corridor side, is the air-well, always connected to the drying yard. These two spaces are the most unique features of the Malaysia apartment plan that appears in every plan we collected. It is owing to the existence of the air-well that the drying yard, which works as a utility balcony, could be located on the public corridor side.

Amongst the ten original plans, those seven plans from 1 to 7 share more common elements than the remaining three graphs from 8 to 10. It can be said the seven plans are typical ones in the market and the last three atypical. Looking at the original graphs at the bottom, it is also recognised that all have the 'open access' connection between the balcony, the living room and the dining room, embedded within the graphs, except for the last plan that has no balcony. We used this graph representation to find out the spatial logic of Malaysian plans under the restriction given by the block plan condition, but now it may be useful to investigate the syntactic connectedness of rooms regardless of the boundary condition. Figure 4.7 shows two different graphs that shows the spatial connections of functional spaces. They are subsets of various original graphs that possess statistically meaningful information. The graph on the left shows all possible connections to the universal pair of 'air-well and drying yard'. Starting from the air-well at the bottom, this graph shows how other spaces make relationship to it in terms of topological depths. Three spaces are connected to the air-well; they are drying yard, a bedroom and a bathroom but with differing percentages. The drying yard unexceptionally (100 %) have a direct connection to the air-well but the bedroom and the bathroom don't always have their link to it—yet as highly probable as 90 and 70 % respectively. The air-well is acting as a quasi-exterior space to support bedrooms, bathrooms and drying yards for ventilation. At the next level of depths, the drying yard also makes three possible connections, but it is the kitchen that is 100 % connected to it like a rule. A bathroom is often connected to the drying yard while a bedroom is rarely connected to it. In sum, it is evident that there is a universal link of three spaces, i.e. the kitchen, the drying yard and the air-well. In the previous graph tree analysis, because the kitchen's position varies from one plan to another, it disappeared during the bottom-up process of finding common elements. It can be said that every apartment plan has this 'K-dy-aw' link, but it is only the 'dy-aw' subset that has a fixed position in the Malaysian apartment building.

The graph on the right in Fig. 4.7 shows all routes from the entrance to the balcony. As highlighted before, the living room and the dining room make a universal connection in every plan. The reason why the balcony has only 90 % is simply because one graph had no balcony; so whenever a plan has a balcony, with no exception, there exists a fully open access route of 'bc-L-D'. The connection from the entrance to the dining room has four different routes and no route seems to dominate the sample. It used to be a single linear open connection from the porch to the back yard in the

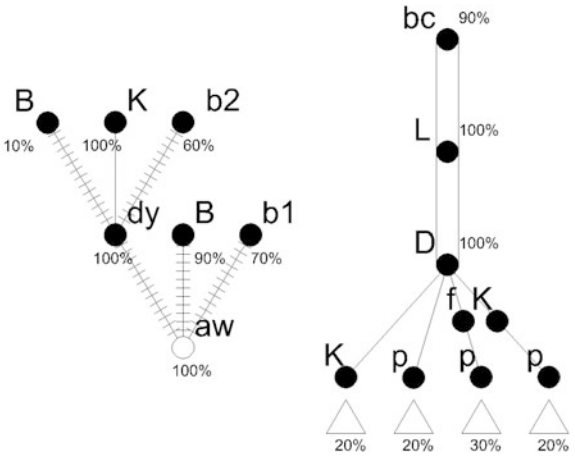

Fig. 4.7 Spaces linked to the air-well (*left*) and the sequence from the entrance to the balcony (*right*)

traditional house, but now the strong linearity has been weakened due to the various types of entrance design. In many cases, however, as we have seen in the graph tree analysis, there are clear efforts to provide open feeling by putting the open living area on the party wall side that is close to the entrance door, and this entails the clustering of partitioned rooms on the farther side of party wall from the entrance. What is another unique Malaysian feature is that every plan has to go through the dining room first before getting into the main living space of living room. In the traditional house, the domestic space followed the order of the male-living at the front and female-cooking at the back, but now it has been reversed due to the new boundary condition of the apartment house. As the living room is placed on the outside periphery of the building block near the balcony for better natural lighting and view, its location had to be separated farther away from the entrance. Consequently, the only entrance door became more like a back door in the traditional house that connects the outside and the kitchen. Now in the viewpoint of a person entering the house from the public corridor, the sequence is following the order of female-cooking in the front and male living at the back, although the periphery of the building where the living room is located is regarded as the front or façade. These findings from the graph-theoretical analysis are important evidences that allow us to make a more objective interpretation of the Malaysian housing genotypes.

4.3 Further Interpretation: Walking into the Malaysian Apartment House

The typical entrance door to the Malaysian apartment unit has an iron grill door added to the original door. It is a supplementary feature for security as well as to help ventilation when the original door is open. On hot and humid days, residents

Fig. 4.8 Integrated public zone seen from the entrance (*left*) and the drying yard (*right*)

can open the entrance door for ventilation while having this grill door shut as barriers to prevent theft. Entering the entrance door, an open interior zone appears (Fig. 4.8). It is an integrated living zone combining the dining room and the living room, and sometimes the kitchen, without partitions. Linked directly to the entrance, it creates the feeling of unobstructed spaciousness which exactly resembles the traditional 'open sequence'. Unlike the traditional house, however, this open zone integrates the living and dining more tightly without transitional spaces. It is true that this is not just a Malaysian phenomenon but a global trend to combine communal functions in modern homes, but in Malaysian case, there exists a strong tendency to align this zone on one side of party walls, nearer to the entrance, and locate the partitioned private rooms on the other, farther from the entrance. This is an environmentally sound solution because when the entrance door and balcony windows are open at the same time, this configuration allows much better ventilation.

A clustering of three essential service spaces, i.e. the kitchen, the drying yard and the air-well, is another defining feature in Malay apartments. It has been revealed from the graph analysis that they are always connected to each other to support various domestic activities. The drying yard is primarily used as a backup space for the kitchen, sometimes equipped with an extra set of gas ranges and sinks as well as washing machines and drying racks (Fig. 4.8). In some bigger apartment units, it is easily found that there are two kitchens, i.e. a dry kitchen and a wet kitchen to provide this backup in a proper manner; thus in compact apartments, the drying yard takes the role of the wet kitchen. In earlier days of apartment

construction in Malaysia, front balconies were utilised as a drying yard, to support the function of washing and drying of cloths, but in recent decades, the function has been pushed backwards by devising a new space, the drying yard. Thus it was inevitable that the drying yard made a new grouping with the kitchen and the air-well to maximize its effect.

Air-wells and indented cut-outs in the façade are important features in Malay apartments which allow more rooms to be exposed to the open air. The architectural code of Malaysia demands that all water closets, latrines, urinals or bathrooms be equipped with openings for continuous natural ventilation [12]. It is not easy to design a balcony-access apartment unit that allows all three bedrooms exposed to the open air without problems. In normal planning approaches, one or two bedrooms need to have their windows facing the access balcony or the communal corridor, which typically causes noise, visual privacy, and security issues. In Malay apartments, these problematic issues have been cleverly solved by having air-wells and drying yards on the access balcony side and the indented cut-outs on the front facade.

4.4 Conclusion

As the traditional Malay house can be characterised by the 'open sequence' of functional spaces, the modern apartment partially adopted this genotype by providing an open spatial continuum from the dining-kitchen zone on the entrance side to the living room and balcony on the front side. These unobstructed family living zone can create open feeling and facilitate natural ventilation. Regarding the design strategy for the room arrangement, Malaysian plans exhibit a clear intention to maximise the open-air contact for ventilation by providing air-wells and deep indents on building facades. Having voids within the building mass, apartment units can overcome the usual limits in room configuration and achieve more depths and flexibility in planning. By using the graph-theoretic method, the cultural elements in their housing form and space could be more clearly quantified and analysed for better interpretation. The remaining question will be how to construct an algorithmic logic of processing the graph representations to speed up the mechanism of filtering out the cultural DNA with more clarity and precision.

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