A stakeholder- and function-based planning method for space-efficient buildings

IOP Conf. Series: Earth and Environmental Science **323** (2019) 012040 doi:10.1088/1755-1315/323/1/012040

A stakeholder- and function-based planning method for space-efficient buildings

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Abstract. Space efficiency has proved to be one of the basic parameters for achieving a high level of sustainability of buildings. By optimizing the required space to fulfil functional requirements, high potential savings can be achieved in terms of space, material and energy consumption. This presupposes, however, that – following the principles of an integrated design process - the use-related functional requirements of buildings have been determined in the early planning phases and that architects take these functional requirements into account accordingly - also with regard to possible organizational, logistic and process-related options. So, interdependencies and (temporal) overlays can be reflected and the topological structure can be transferred into space-efficient spatial structures. But adequate tools and methods are currently missing that support this process of user-based functional demand planning in the sense of an integrated participatory process. This contribution introduces a methodology for early planning phases, which is based on a stakeholder analysis and helps to specify process-related user functions as well as qualified functional correlations. The functional relationships can be described, for example, spatiotemporally or in relation to the flow of materials and can be mapped in an adjacency matrix. The planner is thus actively encouraged to think about area- and space-related optimization potentials and can transfer the topological structure of functions into an space-efficient floor plan concept. Also a prototypical implementation of this method will be presented as a web-based tool that supports a participatory user and stakeholder-related planning process.

1. Introduction

To implement sustainability strategies in the construction sector holistically, a rethinking of pure technical (eco)-efficiency strategies is necessary that includes also social and user-related considerations and sufficiency strategies [2, 3, 4]. Only after the analysis and reflection of the real functional demands of building users, we can answer the question of 'how much and what kind of resources are used for achieving the desired purpose', needs and functions' and offer a quality response to these needs [1]. Boulanger [3] speaks about the 'Satisfaction/Service ratio' with the superordinate goals of well-being, happiness or needs satisfaction.

In the construction sector, an important starting point is the fundamental question about the construction volume or space that is necessary to fulfill the relevant user functions and to enable an adequate execution of processes. Thus, space efficiency is one of the key factors for achieving a high level of sustainability of buildings. By optimizing the required space to fulfill functional requirements, high potential savings can be achieved in terms of space, material and energy consumption.

This is particularly evident in the field of residential buildings. Housing is currently one of the most important and much-debated topics of architectural design in Europe. Due to current political and sociological changes such as migration growth, demographic change and urban-rural movements, the demand for affordable and sustainable living space is growing. The latest changes in legal framework conditions for the densification of existing urban structures in Germany exemplify the urgency of the problem [4].

The topic of space- and thus resource and cost-efficient construction gets a special meaning here. However, space efficiency can only be achieved, if the implementation of the functional requirements

is taken into account in a systemic manner to create adequate and sustainable building structures and typologies.

A look at the available planning literature and construction practice, however, shows that standard solutions and traditional typologies are used without any reflection. They represent current energy-saving regulations but are hardly capable of dealing with the current sociological changes in the resident respectively family structures and also in the living behaviour.

Standard literature such as floor plan compendia for dwelling houses (for example the German 'Grundrissatlas Wohnungsbau' [6]) focus mainly on the subject of single-family dwellings and floor plan typologies, which originate from the 1950s and thus serve primarily family structures such as the classical nuclear family and a very traditional understanding of roles. These are in today's time, however, from a sociological point of view, hardly available and desirable. Unfortunately, there are hardly any planning aids and generalized examples of new approaches such as residential communities, intergenerational living or cooperative housing. The ever more popular approach of minimal and often modularized Tiny Houses [7] provides first good approaches to space efficiency, but focuses – often combined with concepts of ressources self-sufficiency - on very specific target groups and can therefore hardly be generalized.

Niklas Maak - Chief editor of the culture department of the Frankfurter Allgemeine Zeitung and a well-known architecture critic - for example, in his book "Baukomplex" [8] calls for a fundamental rethinking of current planning practice and explains the need for the development of new user-related typologies that can adequately serve today's functional and structural needs of different user groups.

This presupposes, however, that – following the principles of an integrated design process - the use-related functional requirements of buildings are determined in the early planning phases and that architects take these functional requirements into account accordingly - also with regard to possible organizational, logistic and process-related options. So, interdependencies and (temporal) overlays can be reflected and the topological structure can be transferred into space-efficient spatial structures.
But adequate tools and methods are currently missing that support this process of user-based functional demand planning in the sense of an integrated participatory process.

This article introduces a methodology and planning means for the early planning phases, which begins with a stakeholder analysis and helps to specify process-related user processes and functions and which supports their transfer into topological concepts and floor plans. The function-based methodology for architectural design has been applied, evaluated and enhanced in teaching design projects for over 3 years now and will be presented with students' design examples in the following.

Application context of these teaching projects has been housing projects as well as hybride buildings that should cover the design principles of mixed-use, flexibility and space efficiency. But the principles of the methodology are generalizable and not limited to a specific typology of buildings.

2. Methodical Conception

One important prerequisite for successful design projects is the existence of a holistic target system that makes the impact of planning activities assessable with regard to the entire life cycle of the planning object or system. Taking into account its interactions with the superordinate systems and stakeholders [9]. From the objectives of this superordinate system, the purpose and utility of buildings and thus the specific object-related objectives and functional requirements (including functional performance) of the planning subject can be deduced. Here, it is important to analyse the value systems, consumer behaviour and development strategies of the clients and also later building users [10], if possible by a participatory process.

If the customer is also the future user, the application of target planning methods and tools [11] can support the direct interaction. In the case of, for example, investor projects or the design of rental properties, in which the future user is not yet (concretely) known, the (functional) needs can be generalized at the level of target groups by means of marketing methods, such as the persona method

[12]. An important mean for the identification of value systems and consumer behavior are socio-scientific approaches of life-world studies [13] like the sinus milieu data [14].

The methodical approach, that bases on this system of objectives, supports the design process on two levels (see figure 1): At the structural level, the development of spatial-functional topologies and spatial structures takes place, basing on the relevant user processes and their interactions.

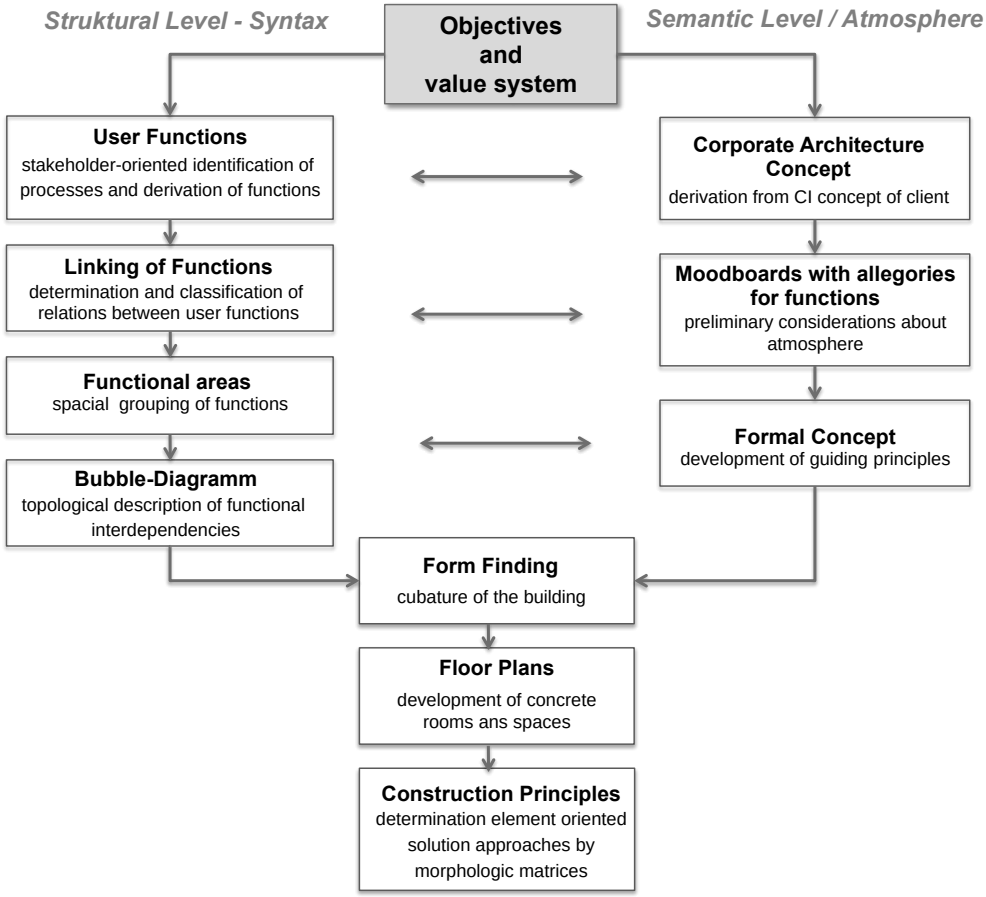

Figure 1: Process-logic of the Function-based Methodology

This process starts with a stakeholder and user analysis and is supported by a so called „structure matrix' - an adjacency matrix, which helps to analyse, qualitatively specify and formalize process-related user functions for the different stakeholders (see figure 2), that should be developed in interaction with the functional requirements in the target system. The analysis and overlay of daily and annual routines of the different users can reveal first relevant correlations. Here, it is very important to specify the functions qualitatively, because it has different spatial consequences.

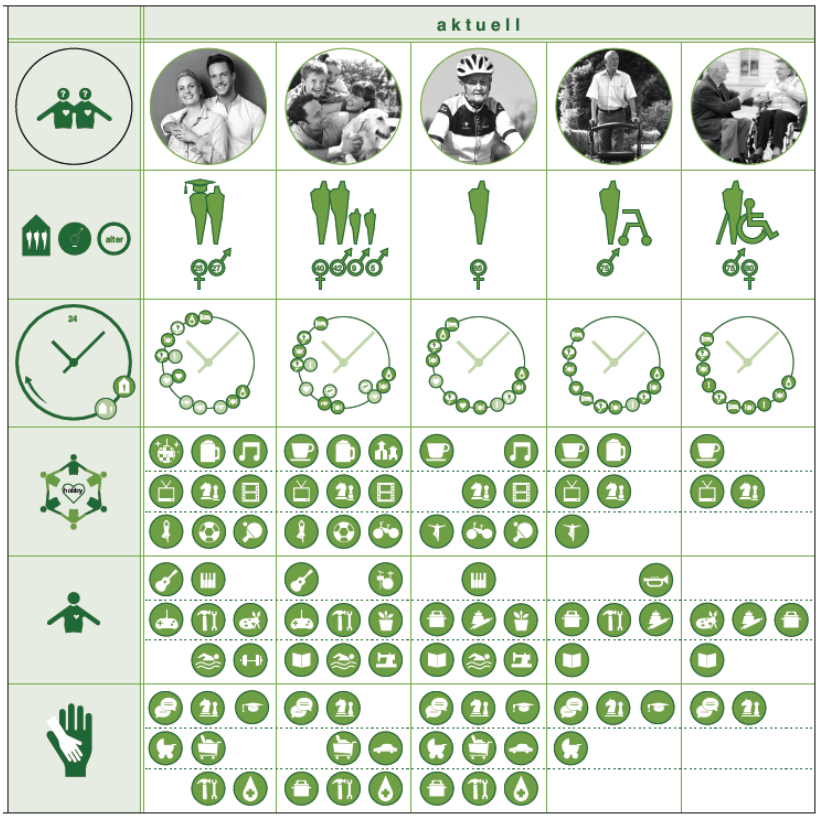

Figure 2: Comparison of Daily Routines of Different Stakeholders, student example of a mixed-used housing project: 'Marketplace of Generations', Noel Rabuffetti 2017 [15]

Currently a student's master project deals with the analysis of the possibilities to apply the methods in the area of healthcare and hospital buildings, which have a very high complexity concerning the logistics. Here the DIN 13080:2016-06 - Division of hospitals into functional areas and functional sections - can serve as a kind of check-list to choose the relevant user functions for the structure-matrix [16].

The next step is the analysis and survey of qualified functional correlations. The use-related functional relationships can be described, for example, spatiotemporally or in relation to the flow of materials or persons (logistics) and can be mapped in the adjacency matrix (see Figure 3). Here, the challenge is to identify possibilities for (temporal) spatial overlaps and mixed-use spaces.

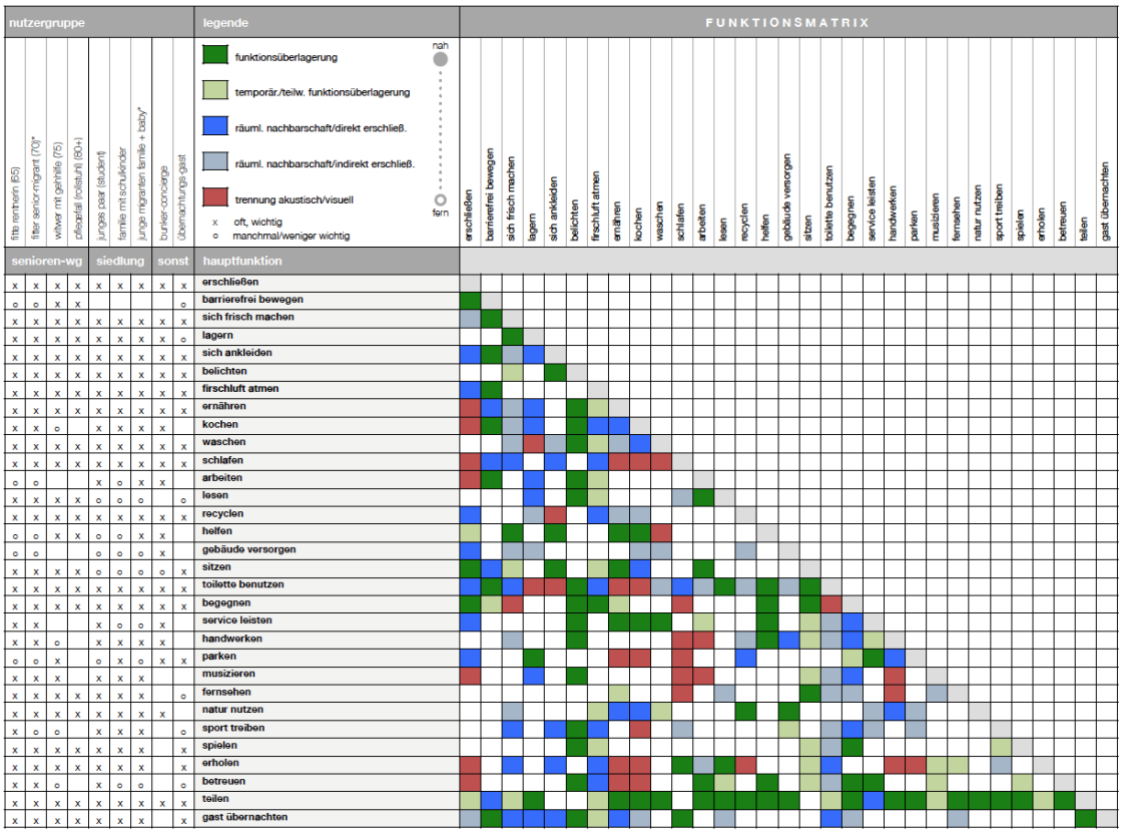

Figure 3: Structure-Matrix for the Analysis of Functional Correlations; student example of a mixed-used housing project, Noel Rabuffetti, 2017 [15]

Considerations about the required technical and physical conditions as well as emissions of the functions with regard to lighting, air conditioning, acoustics and other aspects, describe additional preconditions for the structural formation process in the sense of a systemic approach. An assessment (e.g. by using ranges from one to five) of functional output and required or permitted Input of the system dimensions serves as complementary base for the mapping and structuring (see figure 4).

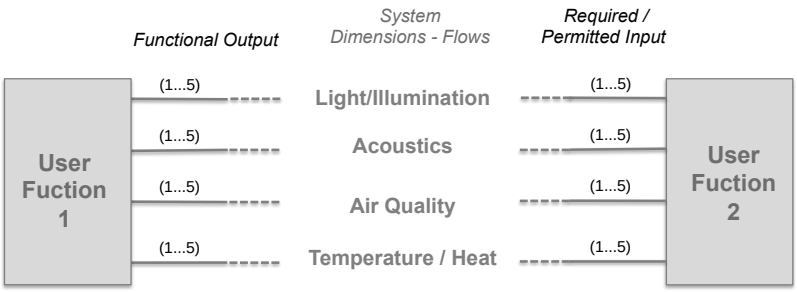

Figure 4: Mapping of Functions with Regard to System Flows

Based on these identified relations and functional conditions, first arrangements of functional groups and areas and for the spatial positioning of functions in the system ‚building' can be made in a reflected way as a first step toward the following space-formation. Here, the functional mapping supports the identification of overlay and flexibility options, which can later be realized, for example, via so-called cluster-flats, a combination of minimized apartments and shared living area and kitchen or so-called joker rooms, which could be assigned to different housing units temporarily.

The planner is, thus, actively encouraged to think about area- and space-related optimization potentials and can transfer the topological structure of functions into a space-efficient floor plan concept. Sustainability assessment systems here also speak about functional equivalence.

A feedback loop with the stakeholder-oriented processes and time-schedules can help to evaluate the logistic quality of the floor-plans.

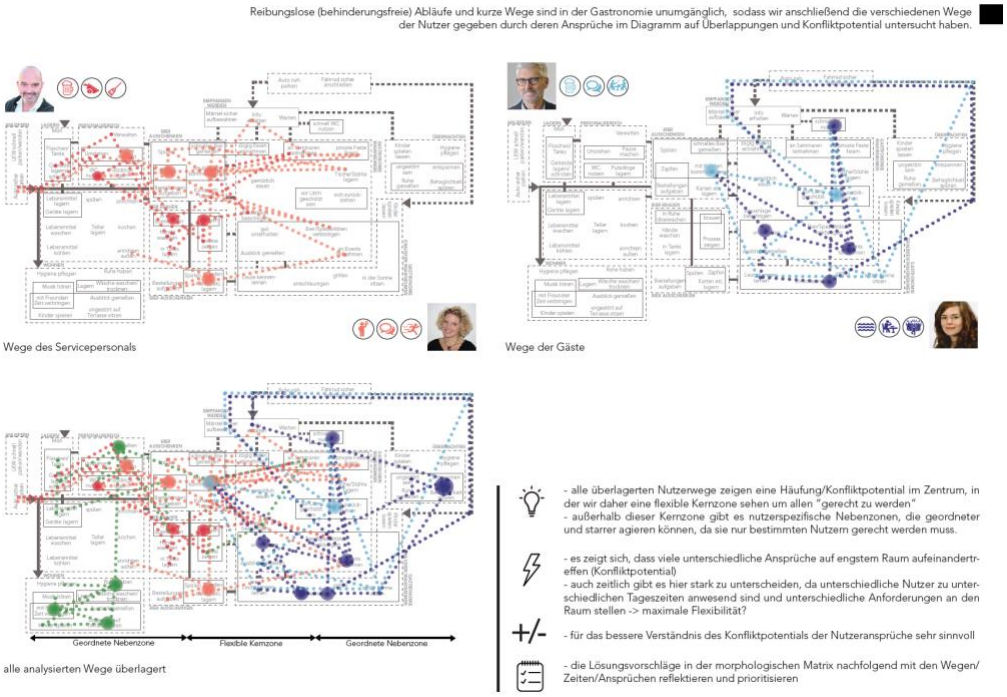

Figure 5: Example of a Students Project: Evaluation of the Floorplan by Overlaying the User Processes, K.Grötsch und Th. Müller 2017, design project ‘ Brewery at the lake’ [17]

To avoid a pure technocratic approach, the building conception in the early planning stages also takes place on a semantic level, in which the designer deals with corporate architecture and questions about the required atmosphere of the functional areas as a basis of later form-finding and spatial design. Here the analysed value systems of the customer helps to develop a specific customer and user oriented architectural statement and semantic.

So, an important step is the elaboration of suitable guiding principles and atmospheric concepts for the identified functions. Working with mood boards, ideographs and symbols for the functions and functional areas supports an abstract and thus more experimental approach, which has been seen to be able to expand the range of solutions consciously. The Maggie’s Centre in Glasgow, a hospital for people with cancer, designed by Rem Koolhaas is a very good example for the creation of a surprising atypical and cosy atmosphere that is conducive to the healing process [18].

The merging of structural and semantic level leads to the reflexive conception of the cubature of the building. Input workshops about form finding methods [19] can enhance the quality of results noticeable. Under consideration of the cubature and the functional topology, now the floor plans can be elaborated. Supported by morphological matrices also first ideas about constructive and design principles can be elaborated. Also on level of the building elements the elaborated strategies for the flexibilisation of spaced shall be implemented by appropriate constructive solutions.

3. Technical Implementation as IT-based Tool

To facilitate the application of the method, a web-based tool, the ‘functionsTool’, has been prototypically implementation of this method will be presented as a web-based tool that facilitates a participatory stakeholder-related design process. The so-called ‘functionsTool’ supports the user oriented development, structuring and grouping of user functions. Based on this, a qualified allocation

of the functions and their spatial-temporal interdependencies can be done. Based on these interdependencies, the tool generates automatically a structural bubble-diagram– an abstract topological graph schema – from the entries and qualified relations in the adjacency matrix. Figure 6 shows a screenshot of the functionsTool with a students' design project - functional conception of a Digital Detox Camp (DDC) using the functionsTool.

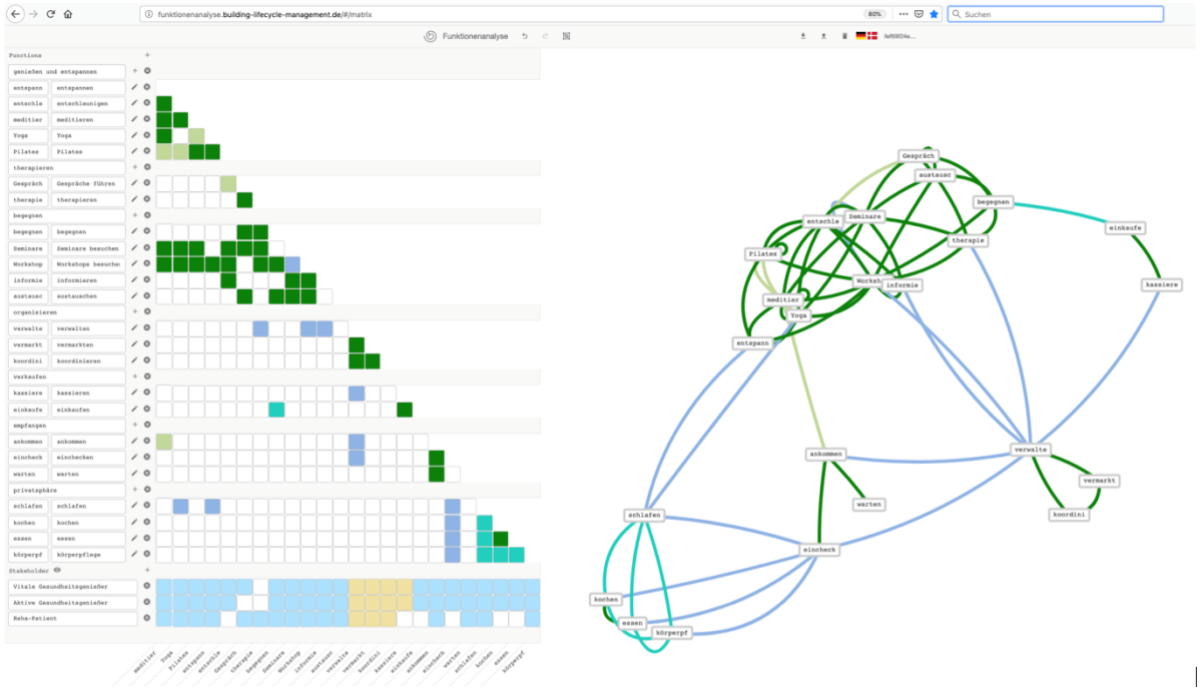

Figure 6: Screenshot of the 'functionsTool' that shows the Structure Matrix and the Automatically Generated Bubble Diagram, (C.Conway and S. Djokic, 2018) [20]

Also, graphics and ideographs can be stored and provided. So, the functional and topological structure of the building can be presented and edited in a transparent and ergonomic way. Here, differentiations in colour allow an easier comprehension and, depending on the quality of the relations, different spatial distances between the functions facilitate the pre-structuring and grouping of functions as base for the next step, the spatial location of functional areas and the geometric room generation.

In a next step, also the specification and representation of system dimensions and their flows as output and input (see figure 4) shall be implemented in the tool. Thus, also the qualified system flows can influence the attraction forces of the functional bubbles and the finally the topology of functional areas.

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