

A compositional schema for the automated generation of best connected rectangular floor plans



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FUNDED BY FCT

Aim



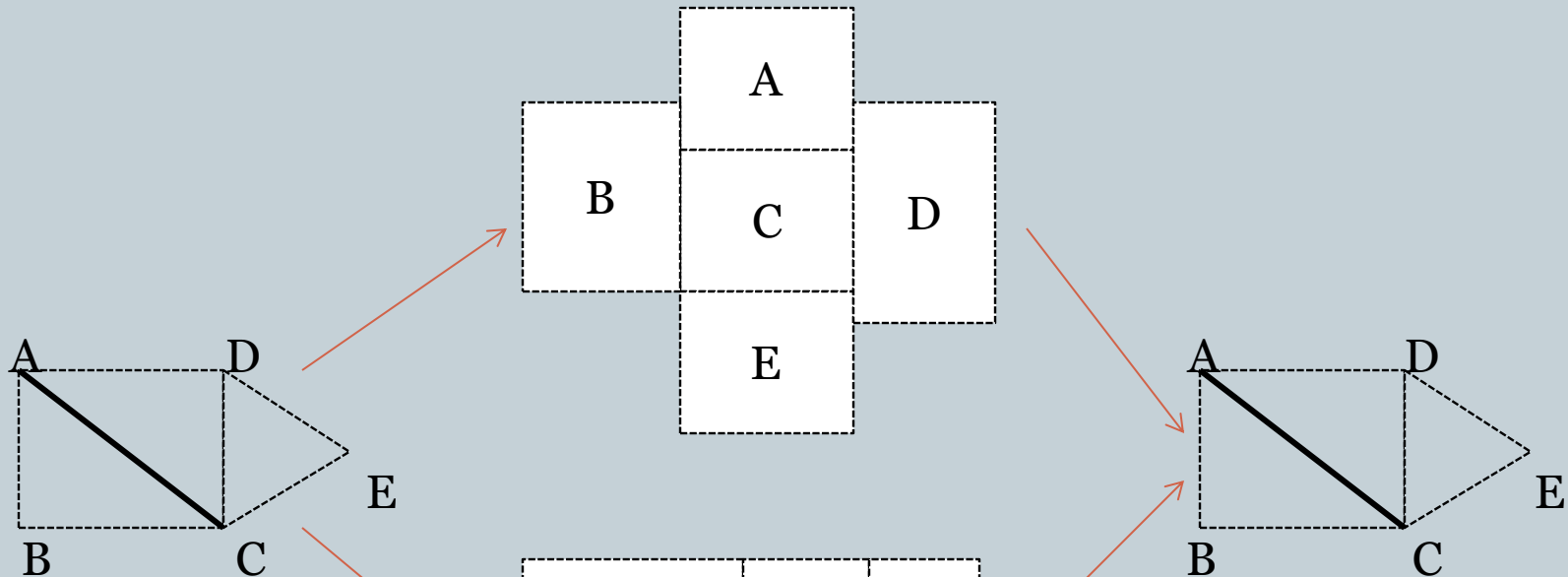
- The work described here is part of a larger research aimed at developing design aids for architects that could be particularly useful in the design of large buildings with complex and specialized programs like hospitals.

Architectural floor plan Design briefs



- Number of rooms
- Shape of the rooms (rectangular or orthogonal)
- Shape of the layout (rectangular or orthogonal)
- Dimensional constraints (area of the rooms and the layout)
- Topological constraints (adjacency relation among the rooms and with the exterior)

Topological Constraints



**Design brief
given adjacency
graph**

**Dimensionless
floorplans**

**Design solution
adjacency graph**

The Space Allocation Problem (Kalay, 2004)



Given:

- n rooms
- Width(horizontal dimension) and length(vertical dimension) of each room
- Adjacency relation among the rooms

Problem (rectangular floor plans):

Fit all the given rooms inside a rectangle while satisfying given dimensional and topological constraints

Planar Floorplan designs



**Floorplan Designs for n
given rooms**

Multi-constraint problem

**Topological
constraints**

**Dimensional
constraints**

**Others(e.g.
view, daylight
etc.)**

Approches



Solving the given problem

- by considering given constraints simultaneaouly (Flemming 1978)
- by considering topological constraints first and then consider the dimensional constraints (Roth et al. 1982)

Best connected rectangular floor plans



The maximum number of edges in the adjacency of a rectangular floor plan with n rooms is $3n - 7$, i.e., a rectangular floor plan is **best connected** if its adjacency graph has $3n - 7$ edges. (Shekhawat 2015)

Design brief
given adjacency
graph

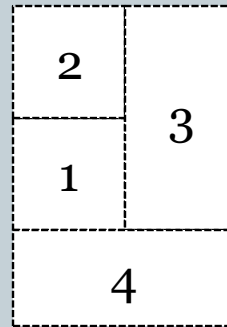
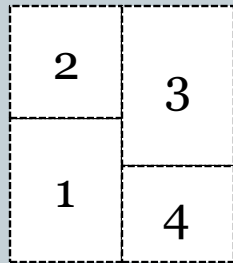
rectangular
floorplan

Design solution
adjacency graph
(maximum $3n-7$
edges)

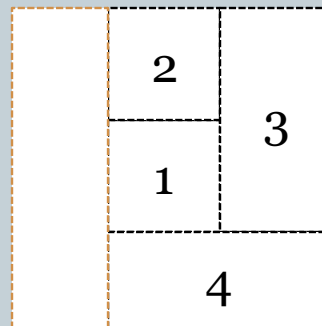
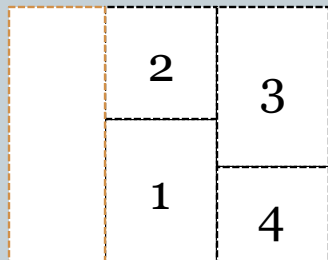
Best connected floor plans



- For $n = 4$, $3n - 7 = 5$.



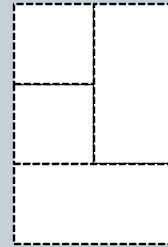
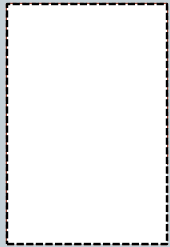
- For $n = 5$, $3n - 7 = 5 + 3 = 8$.



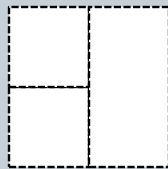
Generation of rectangular floor plans



- Dissection (Krishnamurthi and Roe 1979)



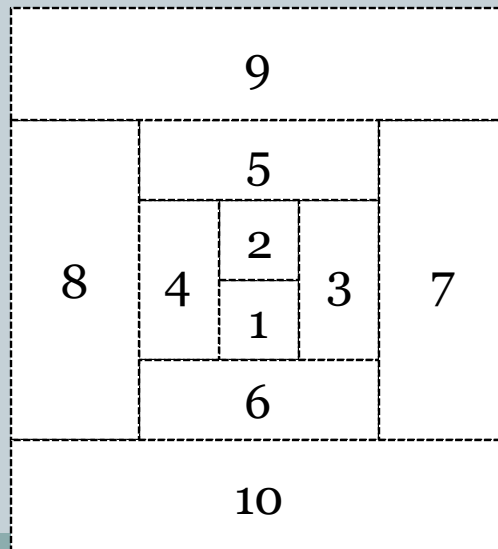
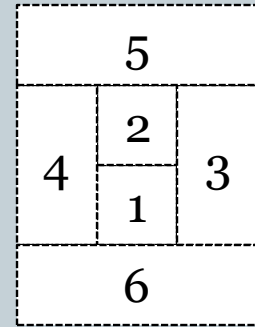
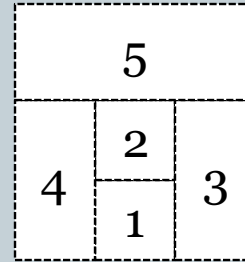
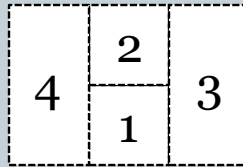
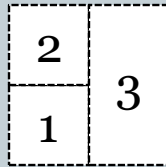
- Addition (Mitchell et al. 1976)



C-RLAB Algorithm



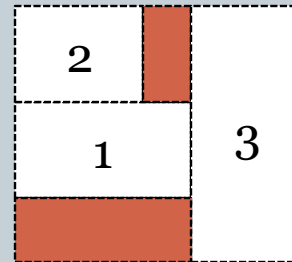
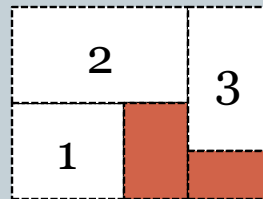
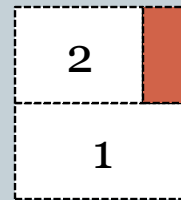
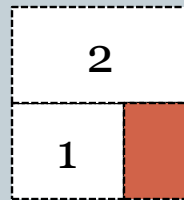
- Topological constraints



Extended C-RLAB Algorithm



- Dimensional constraints



Optimization techniques



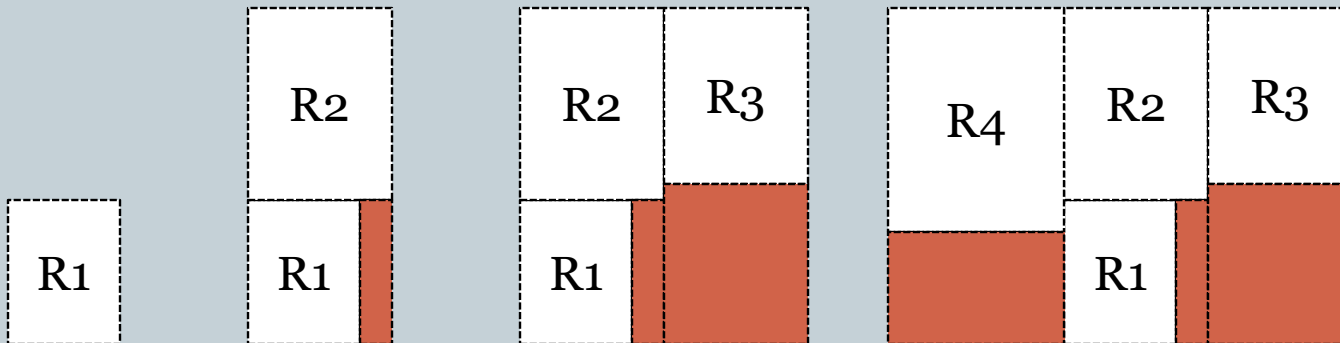
- Order of allocation ($n!$)
- Swapping of width and length (2^n)
- Total solutions: $n! \times 2^n$

Example



Given 4 rooms:

$R_1(10 \times 15)$, $R_2(12 \times 18)$, $R_3(12 \times 16)$, $R_4(16 \times 20)$

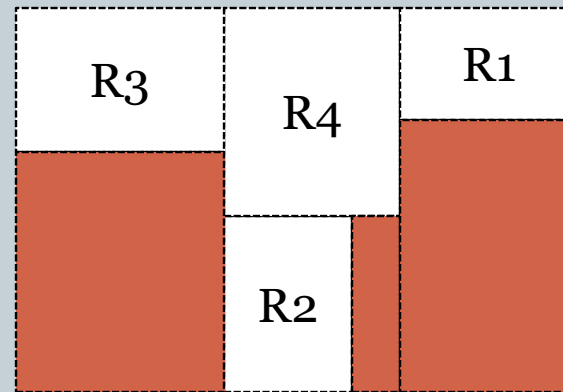
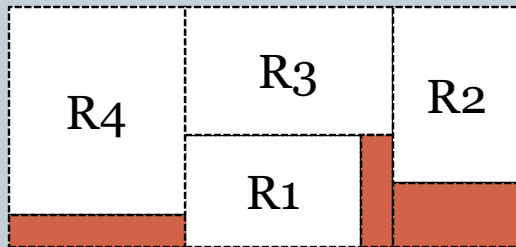


Area = 1320

Reducing the size of extra spaces



- Total solutions for 4 rooms: 384
- Minimum area: 968
- Maximum area: 1786



Future work



- Identify other best connected compositional schemas
- Consider other architectural constraints
- Identify circulation paths

References



- Y.E. Kalay, Architecture's New Media (Principles, Theories, and Methods Of Computer-Aided Design), The MIT Press, 2004.
- R. Krishnamurti, P.H.O'N. Roe, On the generation and enumeration of tessellation designs, Environment and Planning B 6 (1979) 191 – 260.
- W.J. Mitchell, J.P. Steadman, R.S. Liggett, Synthesis and optimization of small rectangular floor plans, Environment and Planning B 3(1) (1976) 37 – 70.
- U. Flemming, Representation and generation of rectangular dissections, 15th Design Automation Conference (1978) 138-144.
- J. Roth, R. Hashimshony, A. Wachman, Turning a graph into a rectangular floor plan, Building and Environment 17(3) (1982) 163 – 173.
- K. Shekhawat, Why Golden Rectangle is used so often by architects: A mathematical approach, Alexandria Engineering Journal 54 (2015) 213 – 222.



THANK YOU VERY MUCH FOR YOUR ATTENTION