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# Assessment of Hierarchical Command and Control organization structures

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# overview

- **Introduction**
  - **Different opinion about C2 structure**
  - **Overview of the Model**
  - **Explanation of the Methodology**
  - **Conclusion**
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# Introduction(1)

Take the  
American army  
for example

- C2 organizational structure is becoming a very urgent task, and a lot of problems are to be solved.
- Our knowledge of C2 organizational structure is **not consistent** with the reality.
  - On the one hand, the traditional pyramid C2 structure is not flexible enough in the face of the information technology and does not respond readily to the battlefield situation, and as a result the battle efficiency is greatly affected[1,2].
  - On the other hand, all government armies, including that of America, all adopt the pyramid C2 structure without exception.

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# Introduction(2)

- The fundamental technological reason: the assessment of C2 organizational structure
    - given a certain organization, how to scientifically and quantitatively decide whether the C2 structure is suitable or not and how suitable it is; if it is not suitable, what is the cause and how to improve it, etc.
  - it is very difficult to construct models, because of:
    - the complexity of C2 organizational structure
    - the interactions involving various factors
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# Different opinion about C2 structure(1)

- C2 structure involves multidimensional, and multilevel interactions.
    - Firstly, wartime command and control relations are based on everyday relations. These include both the formal organization relations and implicit, informal ones. All of them are gradually formed and strengthened during long-time non-wartime activities such as learning, training, rehearsing and preparing.
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# Different opinion about C2 structure(2)

- Secondly, in the aspect of horizontal associations, longitudinal command and control relations and horizontal function allocation, region allocation, etc. form the organizational structure, which is the basis of organizational operation. Behind the static command and control relations between units of C2 structure, there is a dynamic mechanism including information exchange, incident handling and so on..
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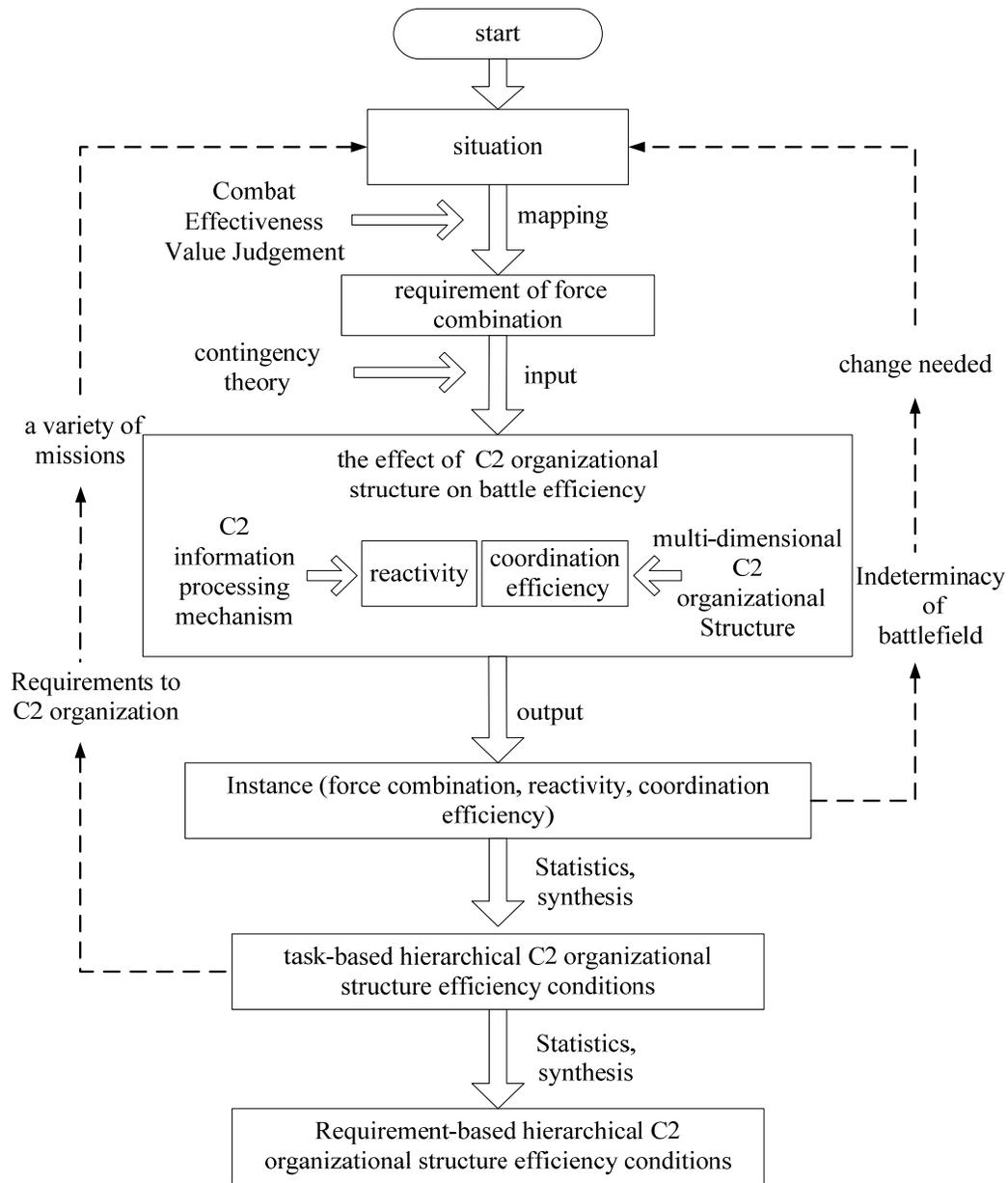
# Different opinion about C2 structure(3)

- Third, in the aspect of application, C2 organization is designed for mission tasks. Usually the task is not specific but within a certain range. This means that the assessment of C2 organizational structure must be based on a certain task range, at least a certain force assignment demand range. Talking about whether certain C2 organizational structure is good or not disregarding task and force assignment demand does not amount to anything at all, for there is no C2 organizational structure which fits every situation.

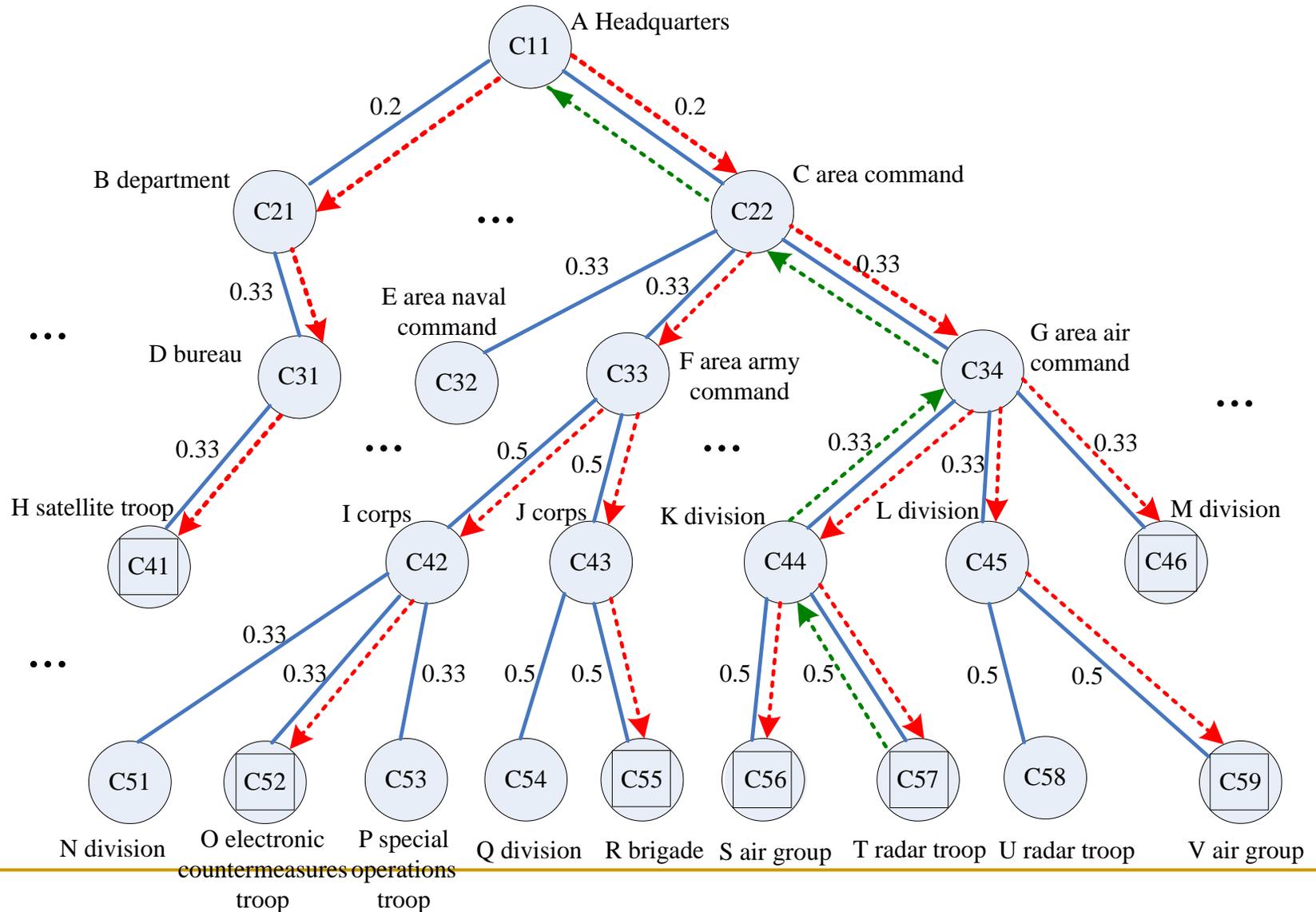
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task-based hierarchical C2 organizational  
structure efficiency assessment framework

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# Explanation of the Methodology



# Reactivity calculating(1)

- For mission M, the responding time of battle force E is:

$$T(E, M) = \max_j \sum_{i \in L(j)} (T_{i1} + T_{i2} + T_{i3})$$

$T_{i2}(1)$

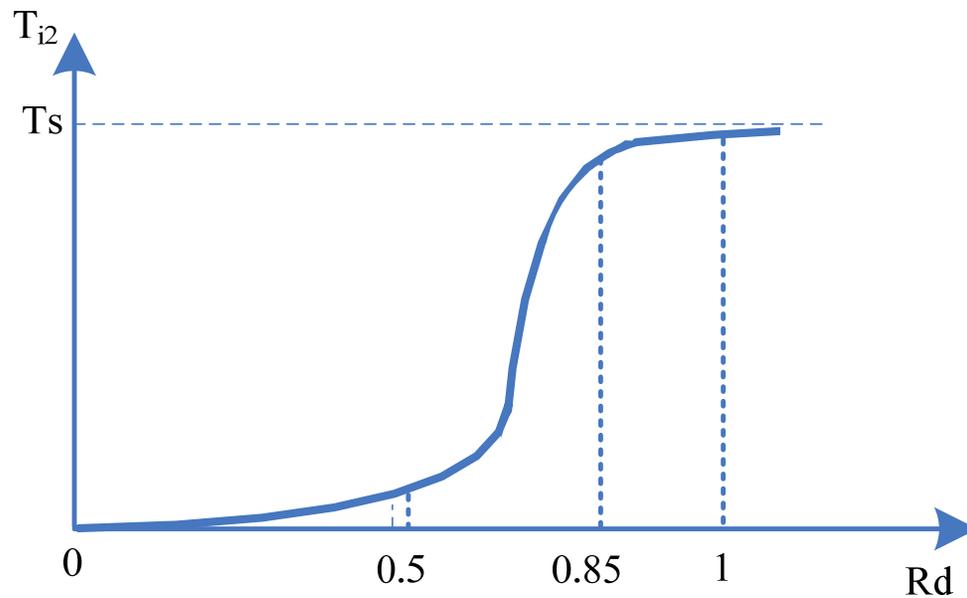
$T_{i2}(2)$

$T_{i2}(3)$

correspond respectively  
to the information  
reception delay and  
information transmit  
time of each node

# Reactivity calculating(2)

$$T_{i2}(1) = K_1 \frac{e^{a+bRd(R_1, R_2)}}{1 + e^{a+bRd(R_1, R_2)}} T_{S_i}$$



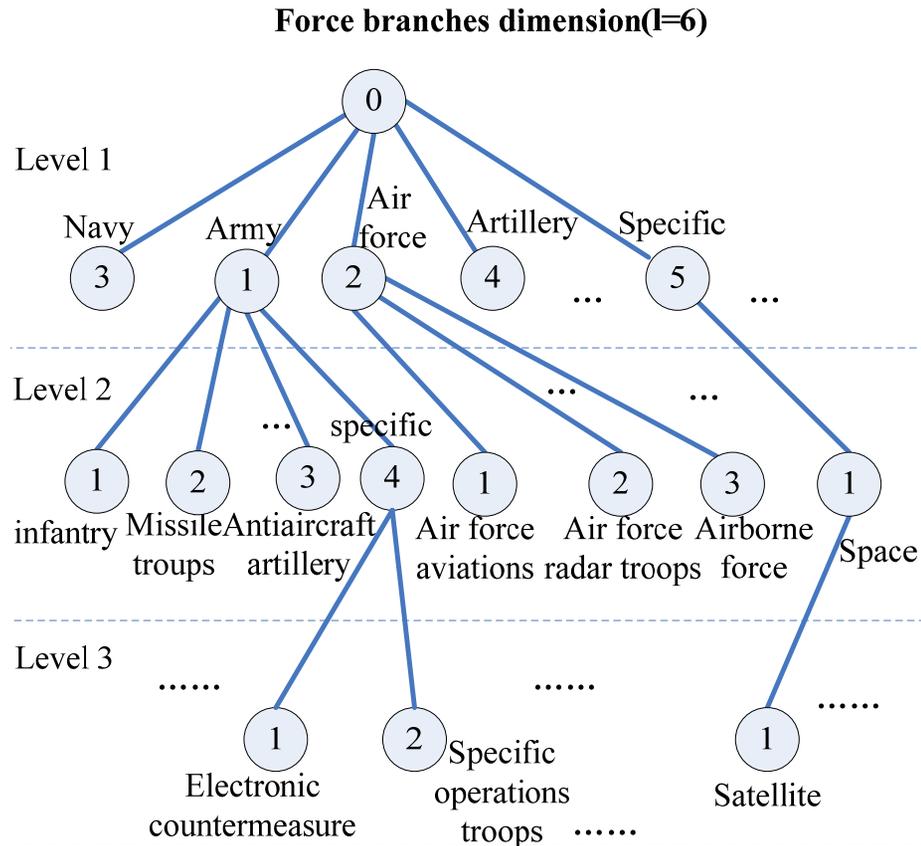
# Reactivity calculating(3)

$$T_{i2}(2) = K_2 \frac{P(R(S))}{P(c(i))} Ts_i$$

$$T_{i2}(3) = K_3 \frac{P(R(S))}{P(c(i))} Ts_i$$

$$\frac{P(R(S))}{P(c(i))} = \sum_{j=1}^n \sum_{i=1}^m \frac{P(rs_i)}{P(rc_j)}$$

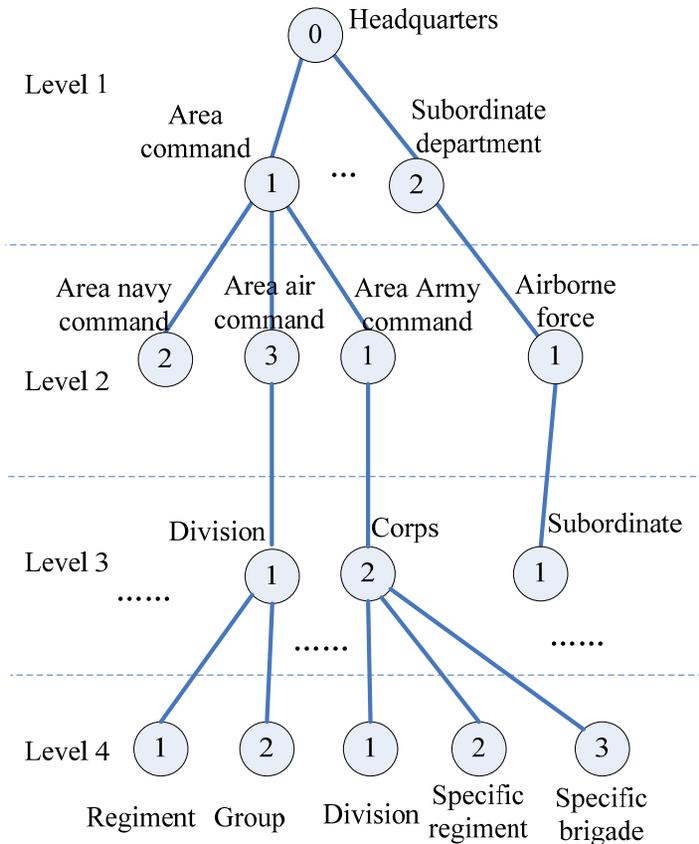
# Coordination efficiency - multidimensional space (1)



(a)

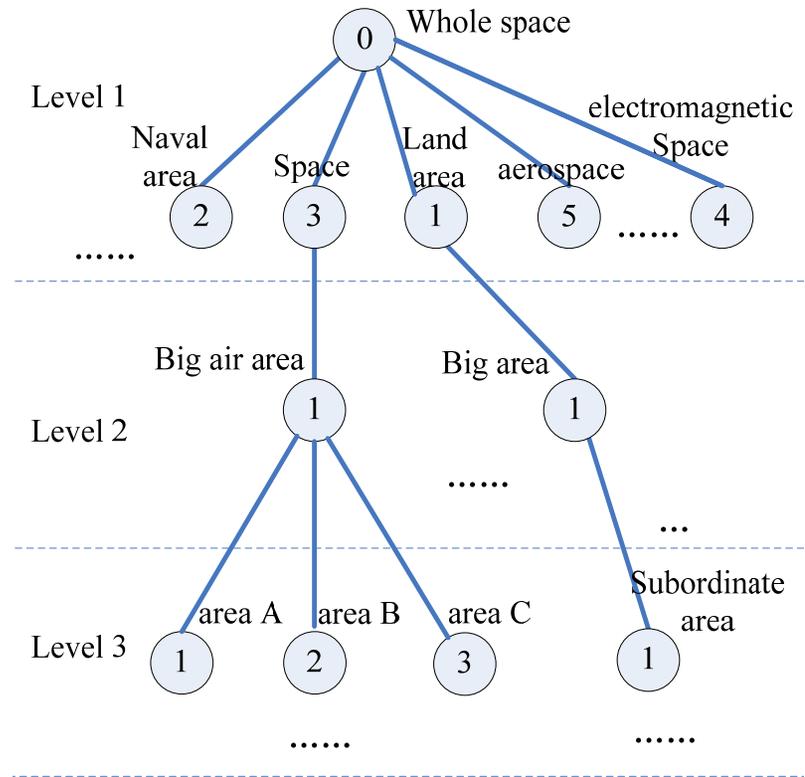
# Coordination efficiency-multidimensional space (2)

C2 level dimension (I=8)



(b)

region dimension (I=6)



(c)

# Coordination efficiency- spatial distance

- The spatial distance between unit A and B can be calculated in the following way:

$$D(A, B) = \sqrt{w_1 d_1(A, B)^2 + w_2 d_2(A, B)^2 + \dots + w_n d_n(A, B)^2}$$

here:  $d_i(A, B) \in [0, 1]$        $\sum_{i=1}^n w_i = 1, i = 1, 2, \dots, n$

# coordination efficiency

- Suppose that the coordination efficiency is inverse relation to their multidimensional space distance:

$$E(A, B) = 1 - D(A, B)$$

$$E(rs_1, \dots, rs_m) = \frac{1}{m} \sum_{i=1}^m \sqrt[m]{\prod_{j=1}^m E(rs_i, rs_j)^{w(rs_i, rs_j)}}$$

# Synthesis

- What any force will face is not a single mission, but a long-term, wide-range possible mission demand.
  - battlefield environment is uncertain, mission demands of forces cannot be predicted and analyzed accurately and mission types and concrete force resource demands will vary in a wide range;
  - the establishment of C2 structure will cost a lot of resources and time, which means the structure serves a mission range.

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# Synthesis practice may be realized by :

- ❑ classifying the possible force combinations or mission types, setting the relative weights, using probability to describe indeterminate factors and then inferring the corresponding force combination according the situation.
  - ❑ However, the results will depend on greatly the knowledge and experience of the specialists.
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# Conclusion

- This paper sets out to assess the effectiveness of forces adopting pyramid hierarchical C2 structure in the respects of reactivity and coordination efficiency.
  - The main characteristic of the assessment methodology lies in that a comprehensive analysis of various factors of C2 structure has been conducted.
    - associating the C2 structure with long-time non-wartime activities such as learning, training, rehearsing and preparing.
    - the *multi-dimensional tree* is introduced to describe the multidimensional space where C2 units are located
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**Thanks!**

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