Process-event in the centre: A S-T dynamic model for the geographic scene

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1. Background

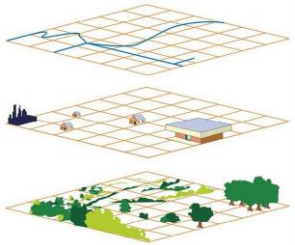
2. Abstraction and Cognition of dynamic in Geographical Scenes

3. Processes and Events in the Center: Geographic Dynamic model

4. Implementation of the Dynamic Data Model exemplified with Typhoon

5. Conclusion and further work

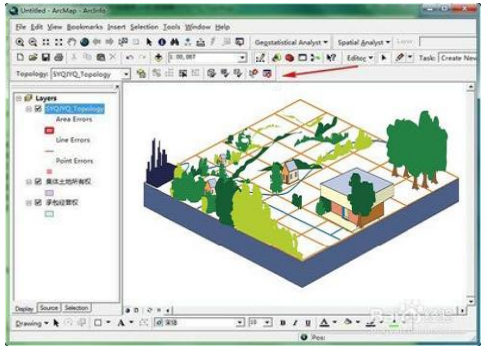
Data organization



Data distribution
by features layers

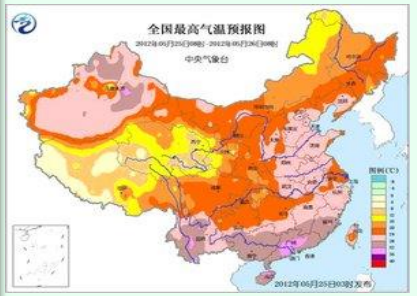
关系	邻接	相交	相离	包含	重合
点—点					
点—线					
点—面					
线—线					
线—面					
面—面					

Topological

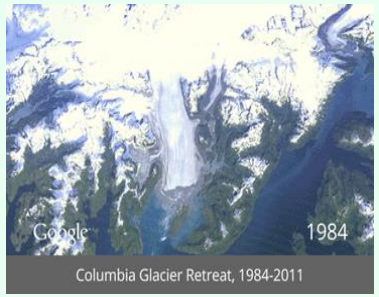


Data integration expression
and organization

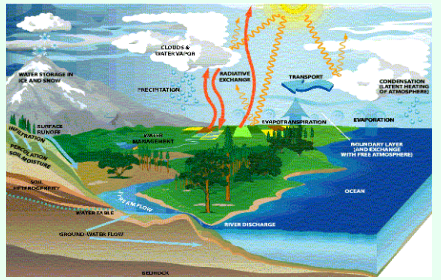
Geographical systems



spatial variation



evolutionary process



interactive relationship

Our focus: development of a data model for representing dynamics

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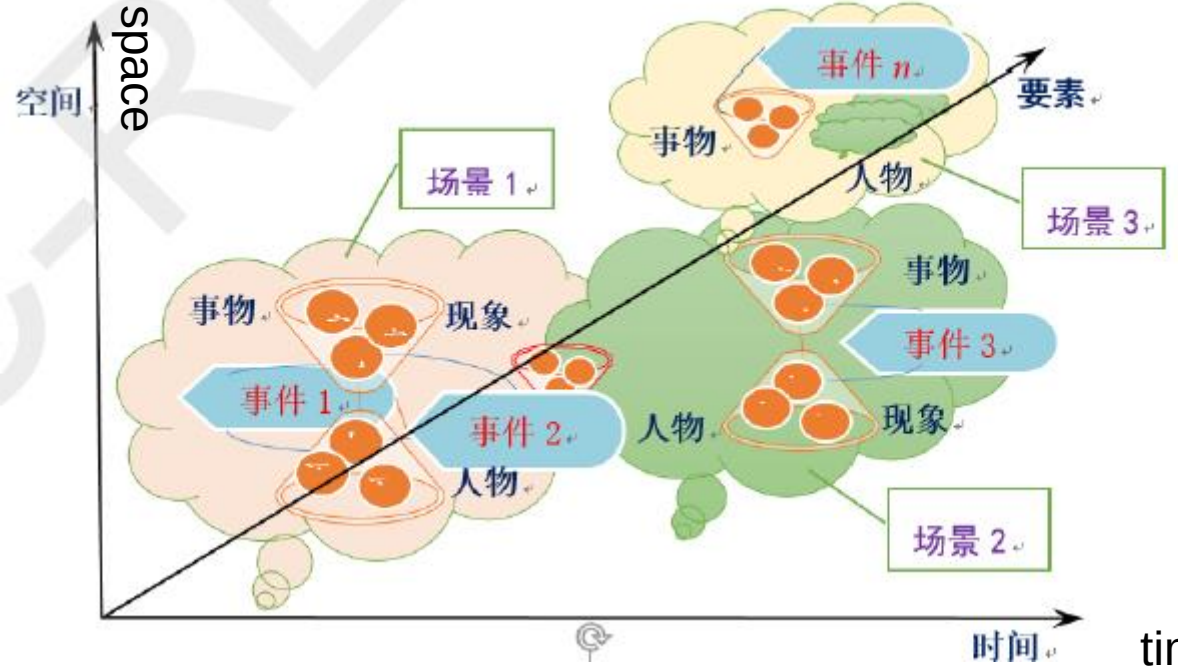
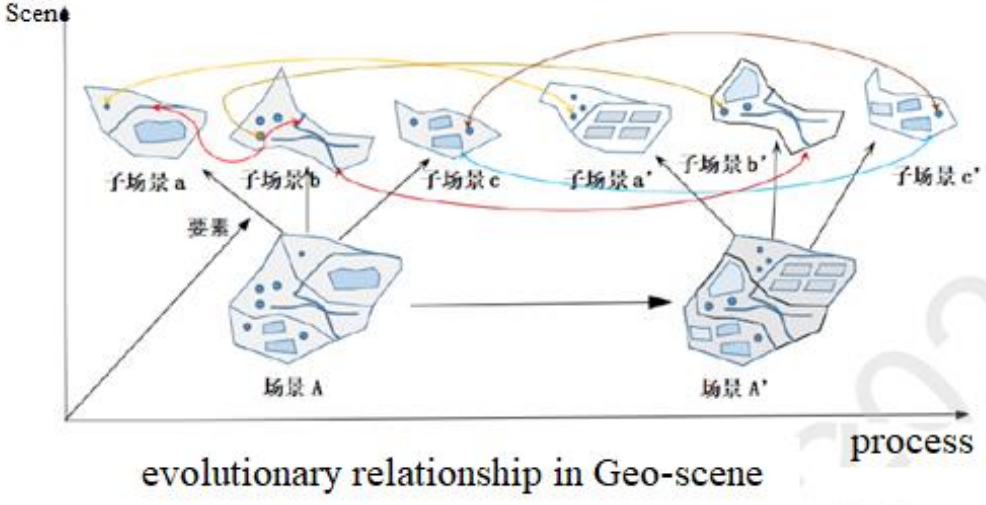
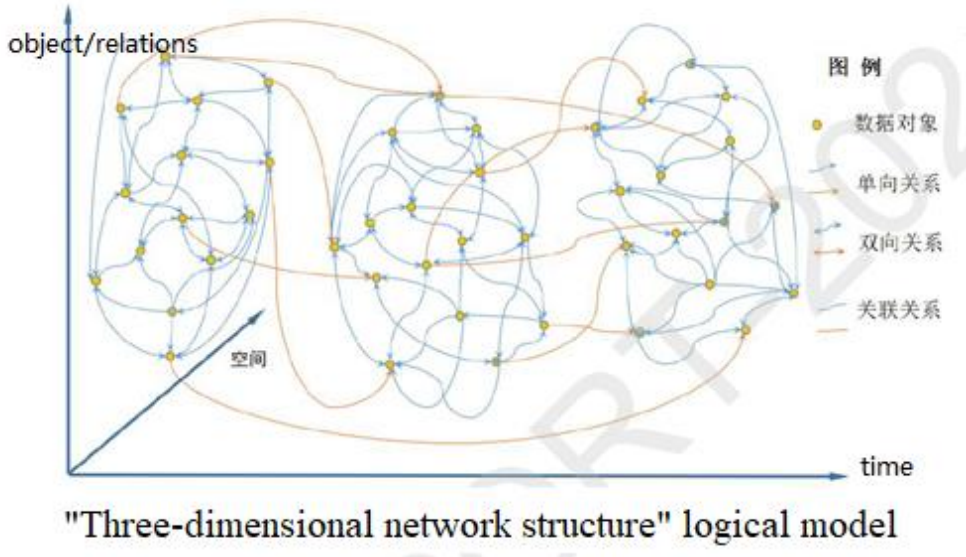
Abstraction and Cognition of dynamic in Geographical Scenes

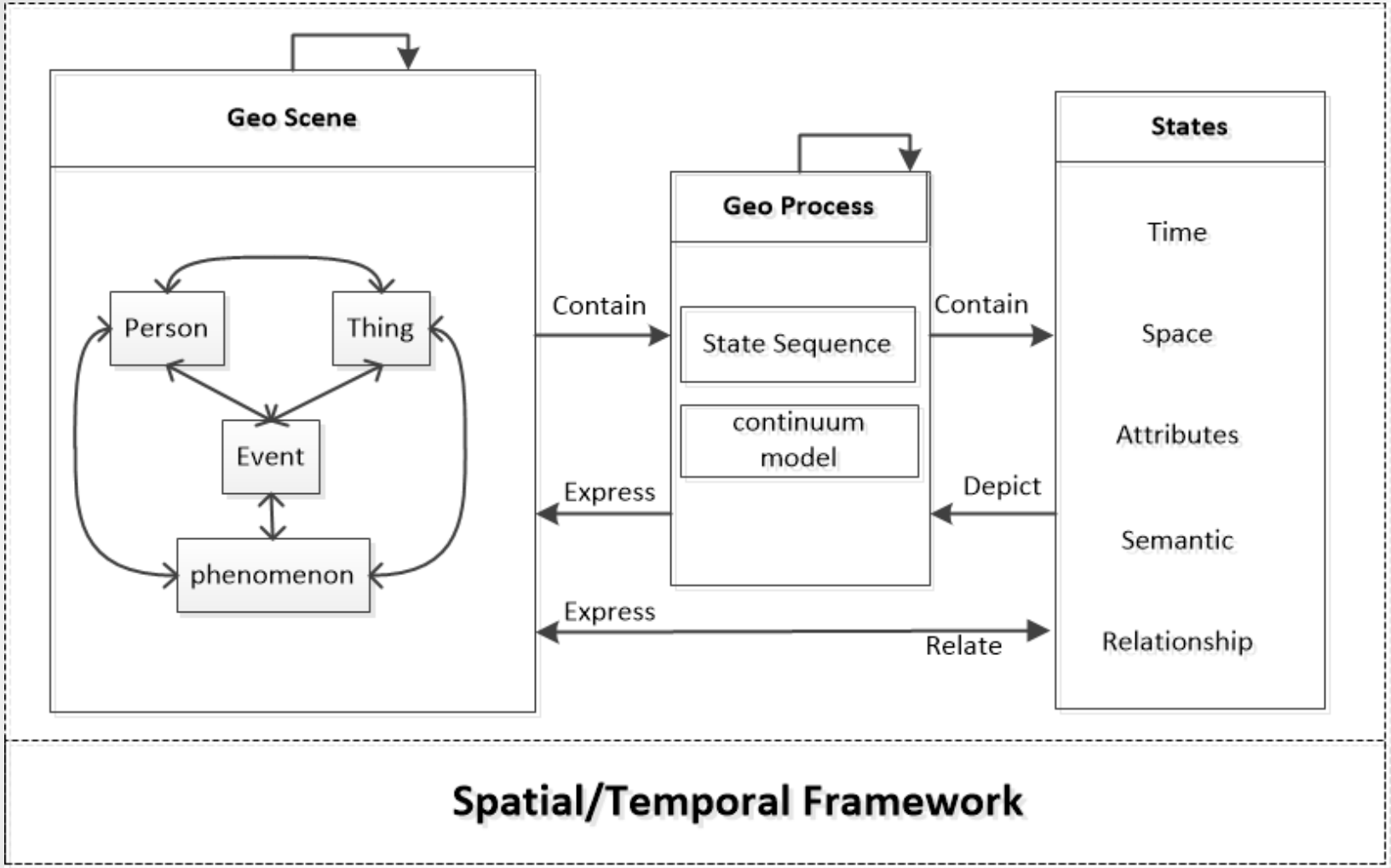




evolutionary relationship in Geo-scene



"Three-dimensional network structure" logical model



Conceptual basis of the new data model:

- Geographic Scene model
- Expresses static and dynamic components of geographical systems
- Event, process, state are the key objects to describe dynamics

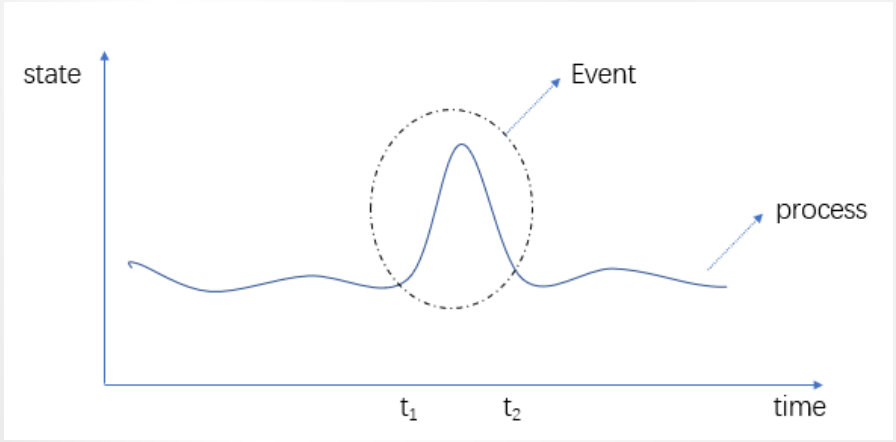
Lu, G.N., Chen, M., Yuan, L.W., Zhou, L.C., Wen, Y.N., Wu, M.G., Hu, B., Yu, Z.Y., Yue, S.S., & Sheng, Y.H. (2018). Geographic scenario: a possible foundation for further development of virtual geographic environments. *International Journal of Digital Earth, 11*, 356-368

Definitions

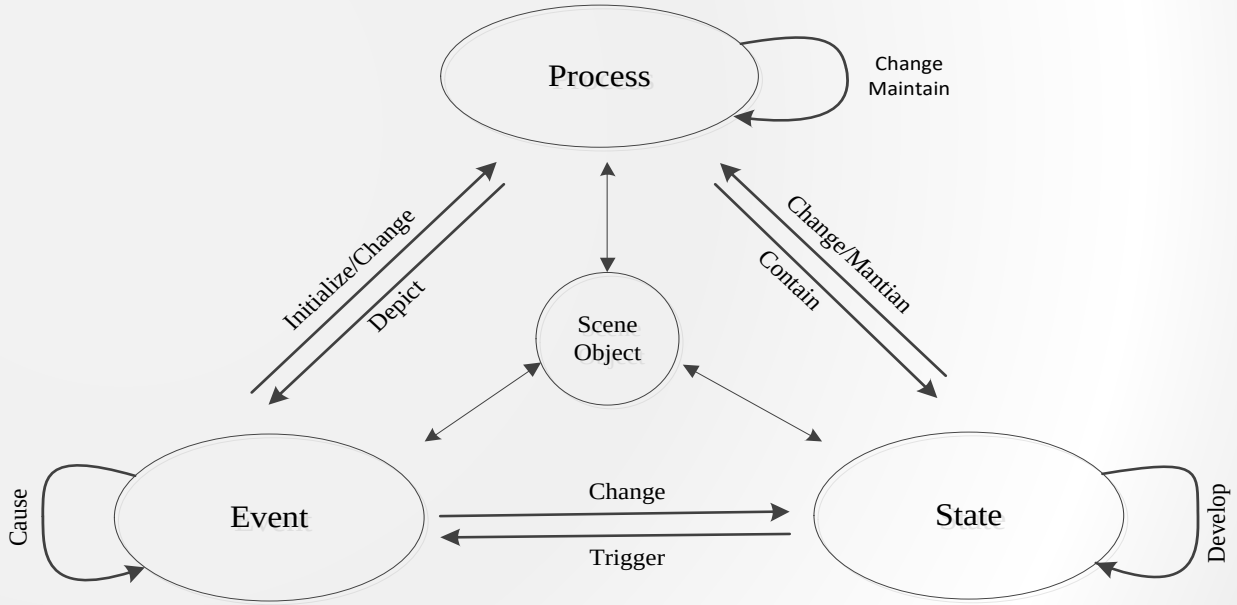
Events: a sudden occurrence, generally refers to something with a considerable influence.

Process： refers to the changes of the characteristics (location, geometry, semantics, properties, interrelationships, etc.) of the geographic object over time.

State： The instantaneous characteristics (semantics, location, attributes, and relationships).



Events as sudden and significant processes



Relationship among event, process, state, and scene object

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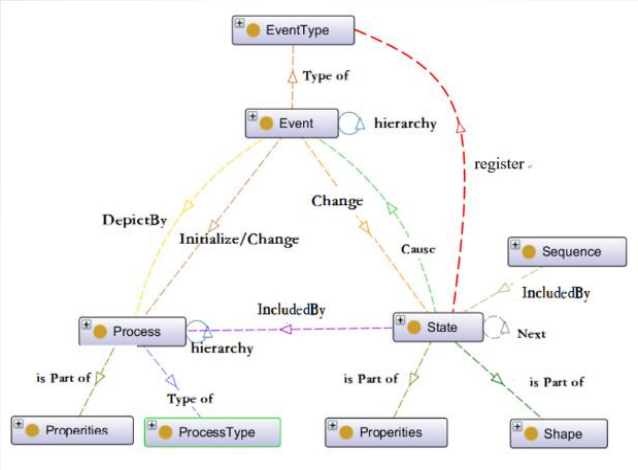
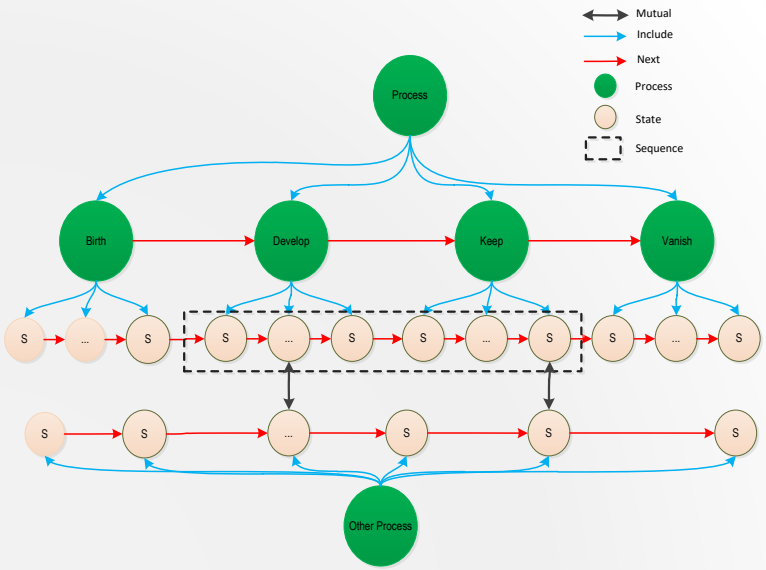
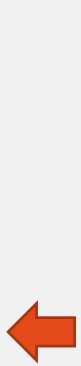
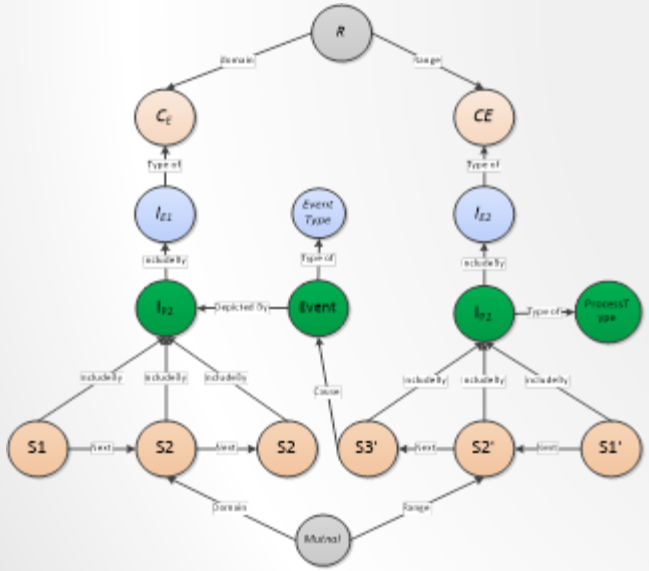


Scene features and relationships in the dynamic change



Geographic process model

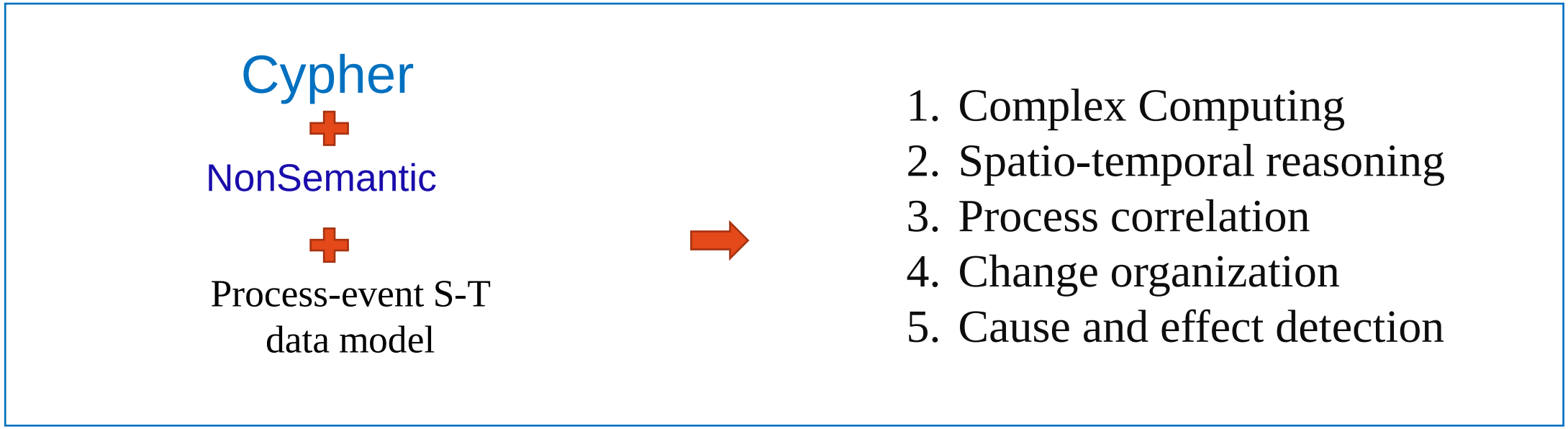




Storage design in dynamic representation model for geographic

Table 1. Characterization table for common geospatial relationships

Relationship Name	Expression style	Transitive	Symmetric	Functional	Inverse-functional	Reflexive
(Include and Include By)	Object Properties	Yes	No	No	Yes	Yes
(precede/Next)	Object Properties	Yes	No	No	Part of it is	Part of it is
Register/Registered By	Object Properties	No	No	No	Yes	Yes
(Cause/Caused By)	Object Properties	Yes	No	No	Yes	Yes
(Depict/Depicted By)	Object Properties	No	No	No	Yes	Yes
(Type of/Instance)	Object Properties	No	No	No	Yes	Yes
(is Part of)	Object Properties	Yes	No	No	Yes	Yes
(contain etc.)	Object Properties	Yes	Part of it is	No	Part of it is	Part of it is
(West To etc.)	Object Properties	No	No	No	Yes	Yes
(Near/Far etc.)	Object Properties	No	Yes	No	Yes	Yes



Model Spatio-temporal Reasoning Capability Implementation

He, Yufeng et.al. 2022. “Processes and events in the centre: a dynamic data model for representing spatial change.” International Journal of Digital Earth.

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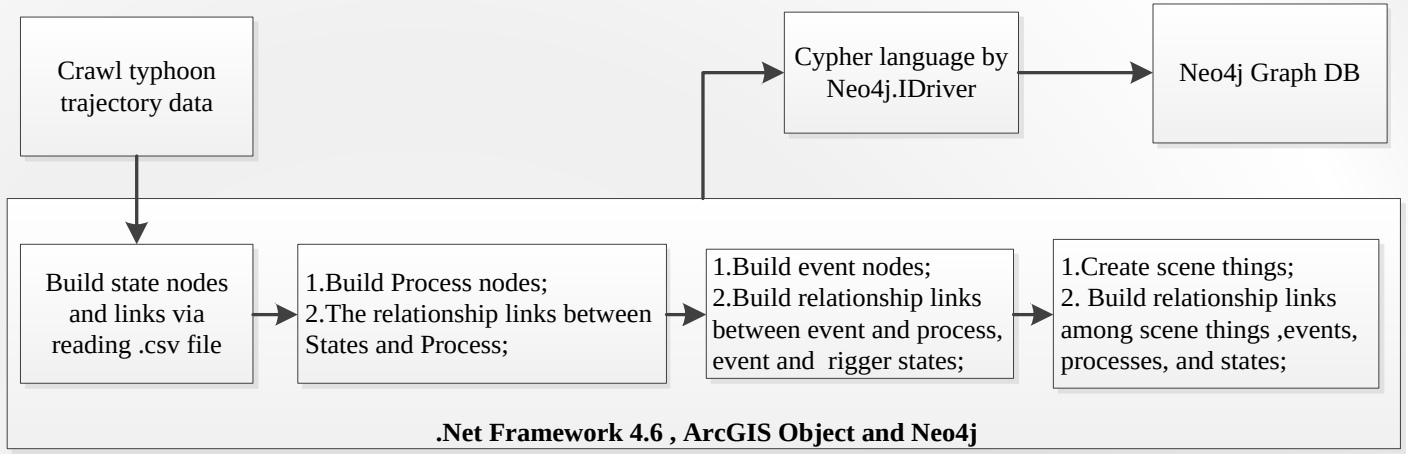
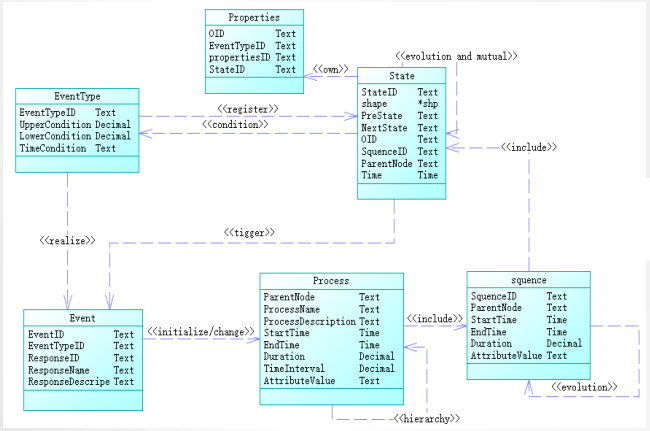
Typhoon Lekima - intensity and trajectory provide source of image



Flow chart of building typhoon model



UML model structure of event, process and state

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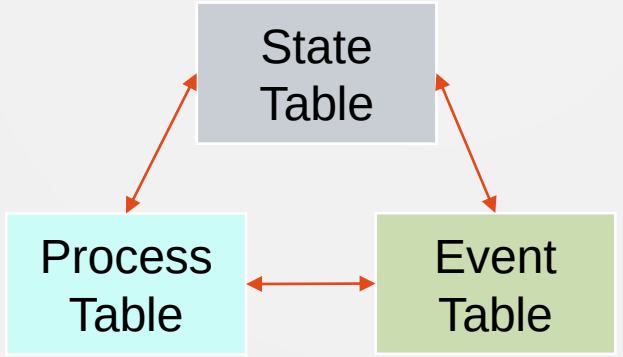

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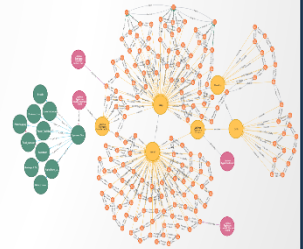
Disaster Data

.Net framework
ArcObject
Neo4j Cypher



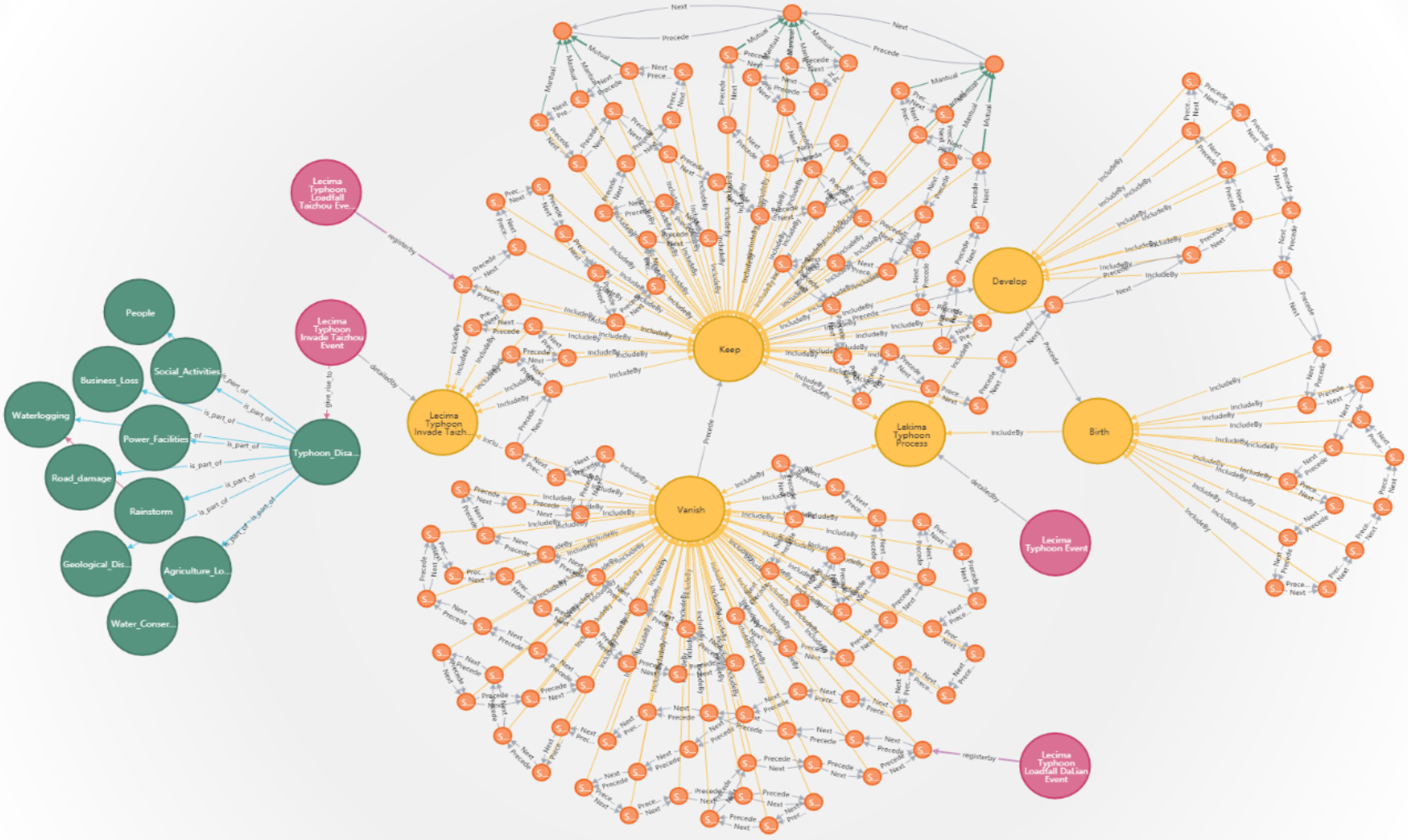
Example

typhoon process

correlation between processes

typhoon disaster information

Typhoon Lekima – schematic diagram of the dynamic evolution model



Dynamic evolution data model of typhoon Lekima based on Neo4j

The Abilities of the Typhoon Data Model

Data organization and complex computing:

- Simple query statement to achieve all typhoon disaster data calculation
- Multiple process operations are interrelated

Q1: What were the damages caused by the Lekima typhoon in Taizhou?

Cypher Language:

```
Match (cat:GeoProcess{Name:"Lekima Typhoon Process"})
CALL n10s.inference.nodesInCategory(cat,{inCatRel:"detailedby",subCatRel:"IncludeBy"}) yield node match
(node)-[r:give_rise_to]->(diaster)
```

Q3: What was the state of the typhoon when the Zhejiang Meteorological Bureau published its third typhoon warning?

Cypher Language:

```
Match (cat:GeoState{Name:"Warning_State1"})
CALL n10s.inference.nodesInCategory(cat,{inCatRel:"Mantual",subCatRel:"Next"}) yield node
return node.TIME as time,node.TSD as Level,node.Direct as direction,node.X as Latitude,node.Y as longtitude
```

Table 6. Results for Q3

time	Level	direction	Latitude	longitude
2019/8/8 7:00	SuperTY	northwest	125.9	22.7
2019/8/8 8:00	SuperTY	north-northwest	125.9	22.7
2019/8/8 9:00	SuperTY	north-northwest	125.9	22.8
2019/8/8 6:00	SuperTY	northwest	126	22.5

The Abilities of the Typhoon Data Model

Query and Reasoning Capability Support:

- Retrieve typhoon landfall data

- Identify the cause of the waterlogging

Q2: What was the landfall information for typhoon Lekima?

Cypher Language:

```
Match (cat:GeoProcess{Name:"Lekima Typhoon Process"})
```

Q 4 What causes urban flooding in Taizhou City?

Cypher Language:

```
Match (cat:Disaster{Name:Waterlogging"})
CALL n10s.inference.nodesInCategory(cat,{inCatRel:"give_rise_to",subCatRel:"is_part_of"}) yield node
return labels(node) as Type,node.Name
```

Table 7. Results for Q4

Type	Name
Disaster	Rainstorm
GeoEvent	Lekima Typhoon Invade Taizhou Event

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Conclusion

- We formalized the relationship among process, event and state from the view point of spatial dynamics.
- A spatio-temporal dynamic model was constructed.
- The model avoids creating many tables and joining multiple tables to get the complex results.
- The model achieves an organizational framework for simulating spatio-temporal dynamics and complex calculations.
- Overall, the model provides complex query and spatial reasoning ability for spatial dynamics.

Further work

- The ability for inference is mostly limited to direct causality, requiring further improvement to indirect causality in the scenes.
- Using data mining techniques - combining causality rules we constructed - to further explore the spatial reasoning in different application situations.

Thanks!

Any question?

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