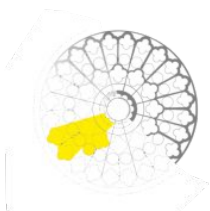
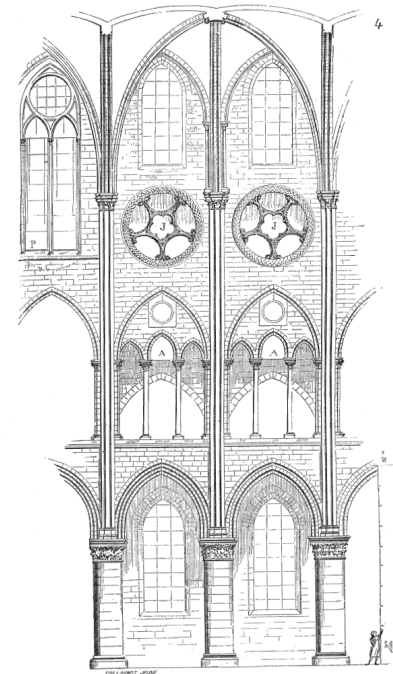
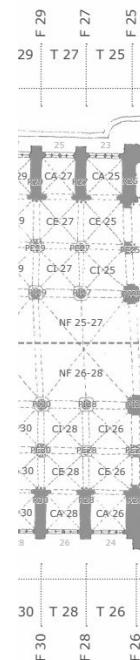


RCC8 for CIDOC CRM: semantic modeling of mereological and topological spatial relations in Notre-Dame de Paris

Anaïs Guillem, Antoine Gros, Kevin Reby, Violette Abergel, Livio De Luca



ndame

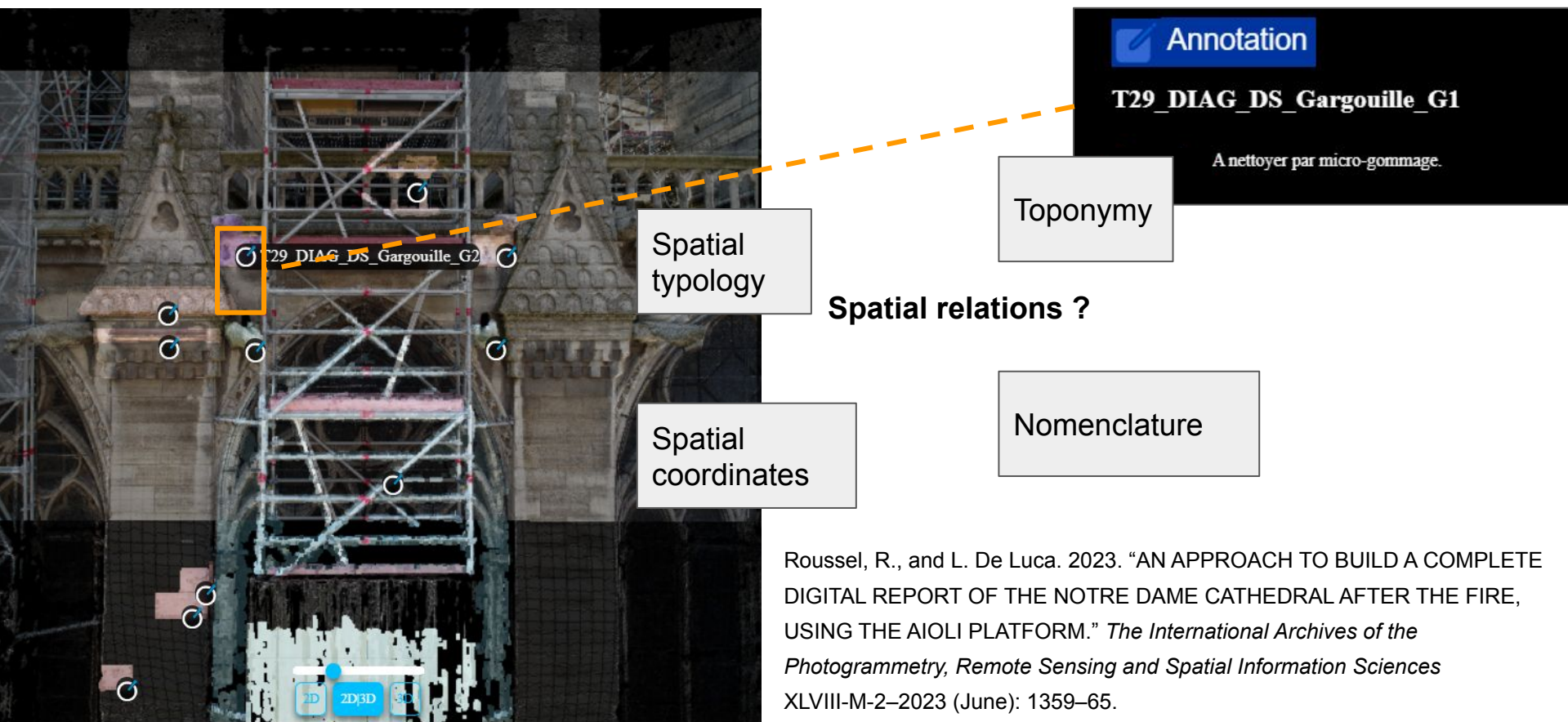
écosystème pour l'analyse et la mémorisation multi-dimensionnelle du chantier scientifique de Notre-Dame de Paris



Laboratoire
de Recherche
des Monuments
Historiques

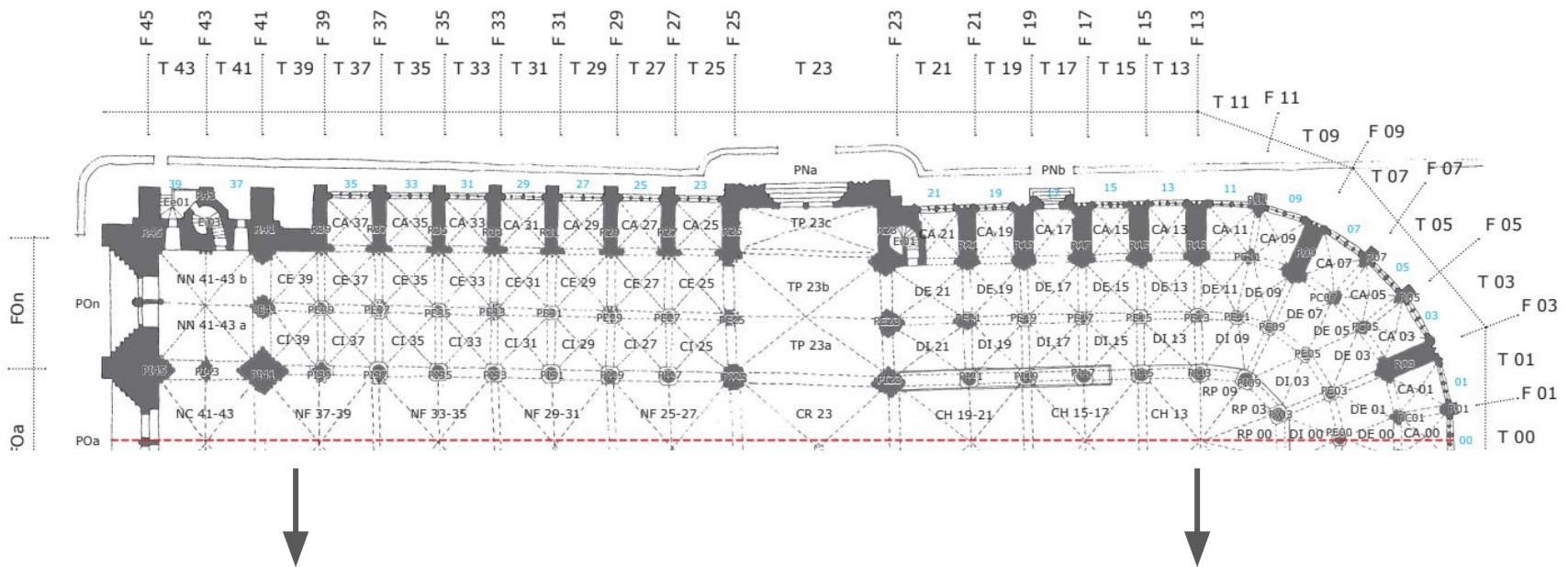
Semantics of Complex Spatial Data

- **Identified problem:** lots of spatial and geometric data (ie. Aioli) but absence of semantics about space and place (modeling, mapping, and querying)
- Place semantics vs. space (place+physical materiality)



Roussel, R., and L. De Luca. 2023. "AN APPROACH TO BUILD A COMPLETE DIGITAL REPORT OF THE NOTRE DAME CATHEDRAL AFTER THE FIRE, USING THE AIOLI PLATFORM." *The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences XLVIII-M-2-2023* (June): 1359–65.

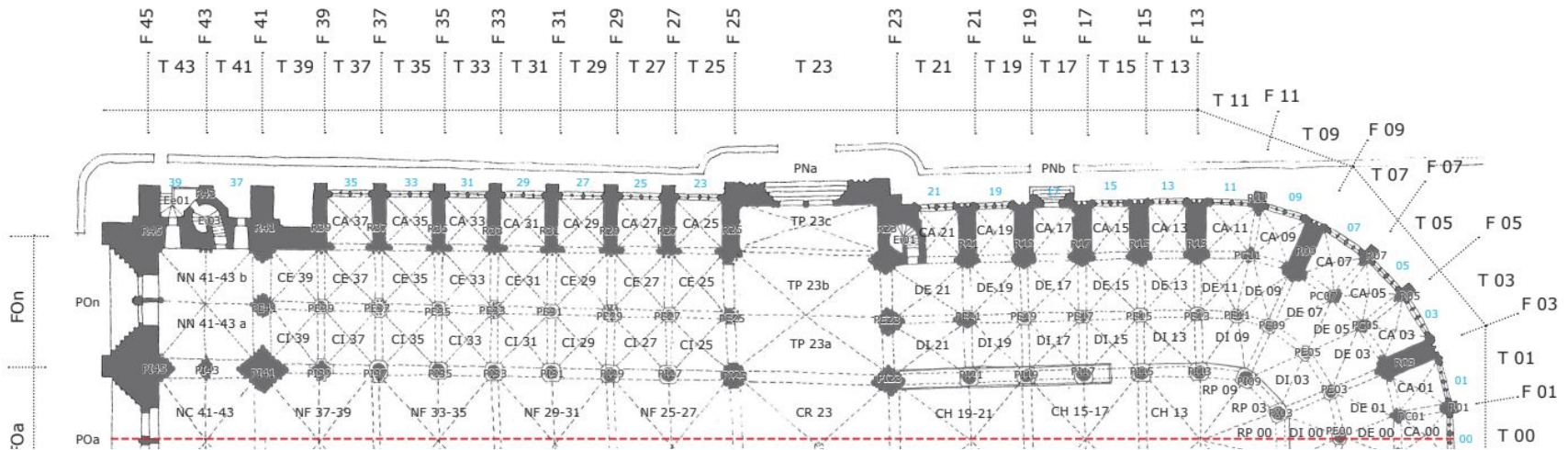
Complex spatial data modeling, mapping, and querying



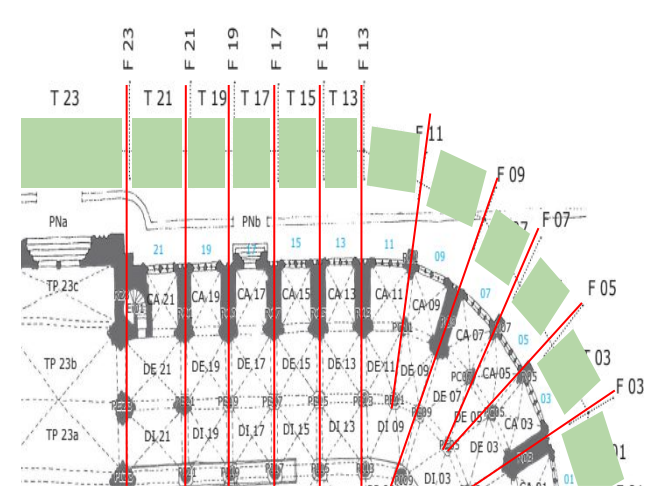
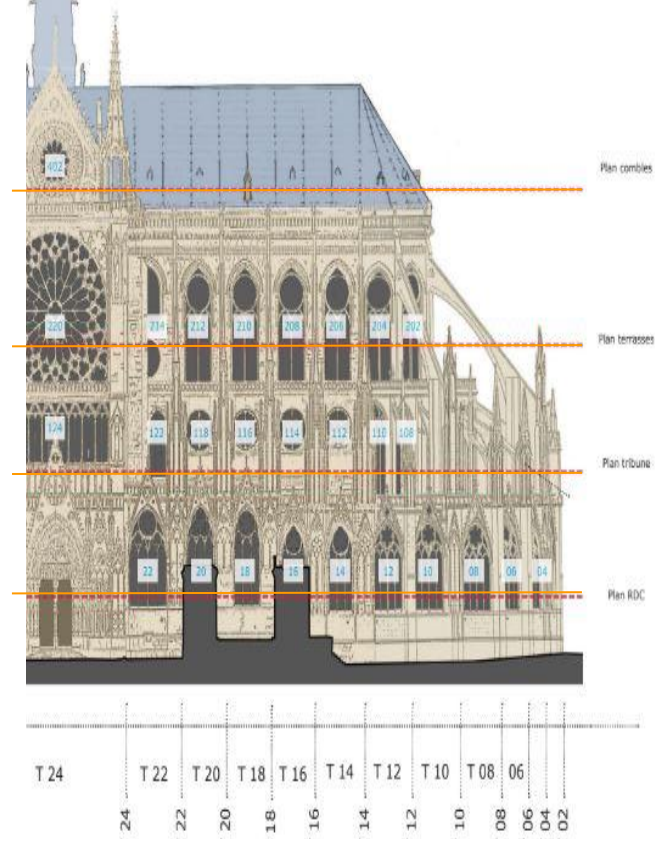
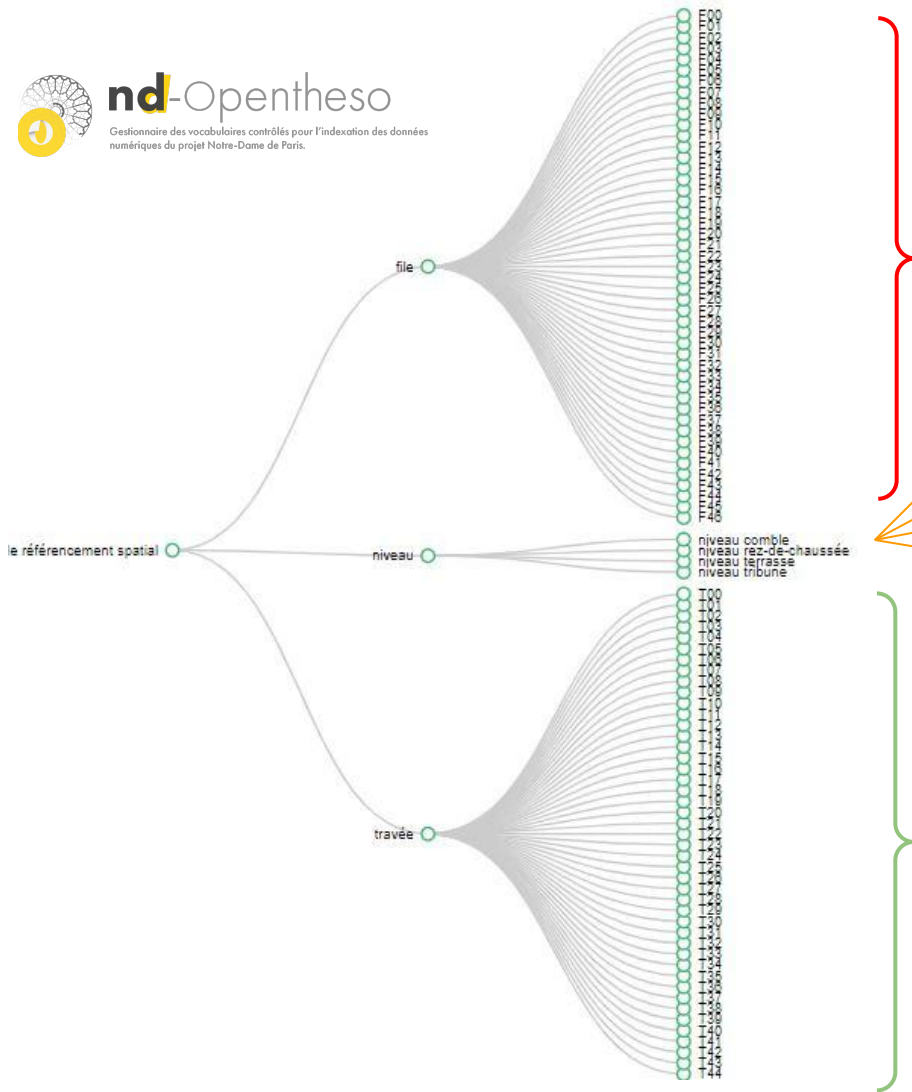
Problem of spatial indexation

what level of description/documentation to adopt for spatial informations ?

Dataset creation: complex spatial data based on nomenclature

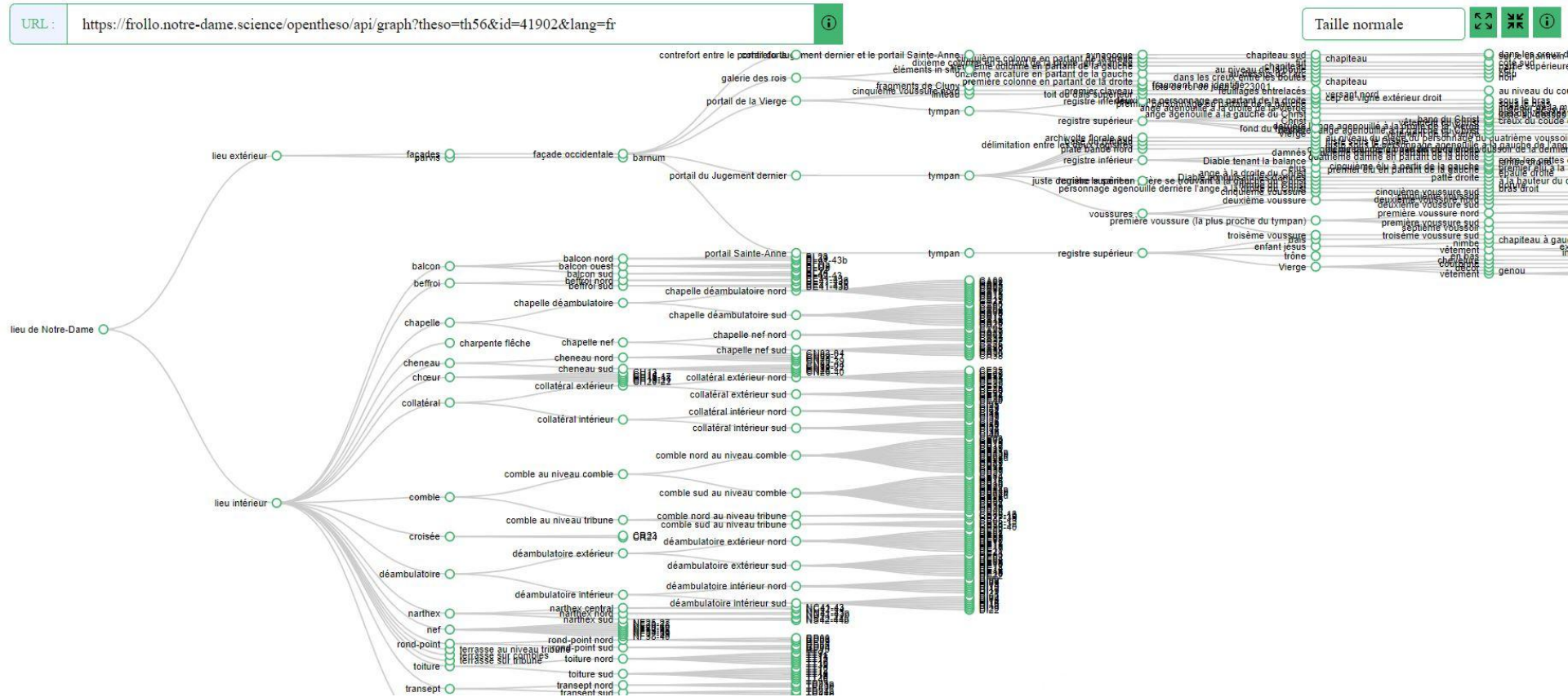


		Id_Nomenclature	File# [F]	Travee# [T]	Vitraux# [00]	Refend# [R]	EscalierExt erieur# [Ee]	EscalierIn rieur# [Ei]
espaces								
narthex			F41;F42;F43;F44;F45 ;F46	T41;T42;T43;T44	0037;0038;0039 ;0040	R41;R42;R45;R 46	/	/
	narthex nord [NN]	NN41-43b; NN41-43a	F41;F42;F43	T41;T43	0037;0039	R41;R45	/	/
	narthex central [NC]	NC41-43;NC42-44	F41;F42;F43;F44;F45 ;F46	T41;T42;T43;T44	0037;0038;0039 ;0040	/	/	/
	narthex sud [NS]	NS42-44b;NS42-44a	F44;F45;F46	T42;T44	0038;0040	R42;R46	/	/

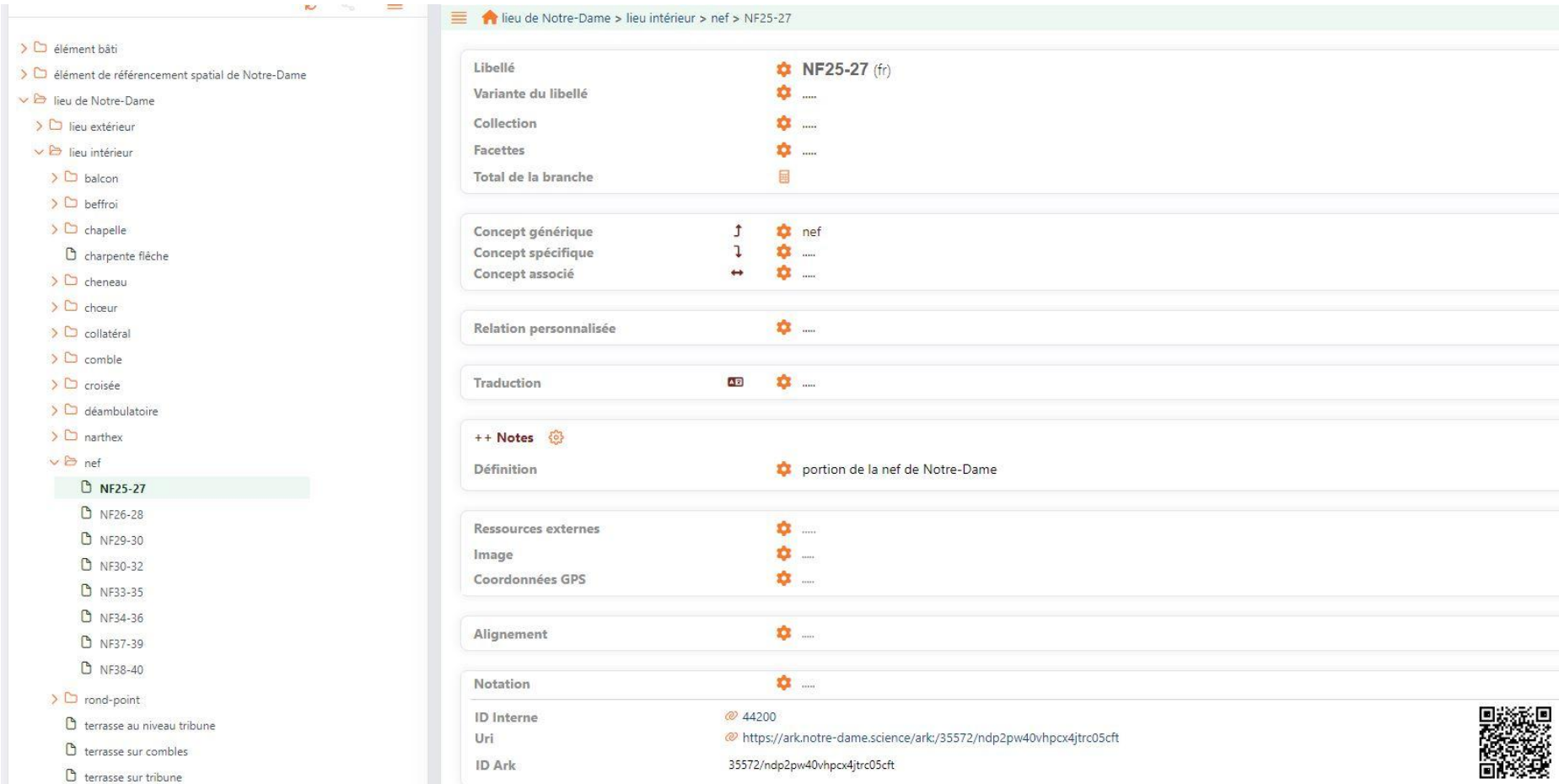


Formalizing the nomenclature as a thesaurus

Th56: 520 places inventoried so far and increasing



Example of place NF25-30 in th56



The screenshot displays the 'nd-Opentheso' interface. On the left is a hierarchical tree view of the ontology, with 'nef' selected. The main panel shows the details for 'NF25-27 (fr)'. The breadcrumb path is 'lieu de Notre-Dame > lieu intérieur > nef > NF25-27'.

Libellé NF25-27 (fr)
Variante du libellé
Collection
Facettes
Total de la branche

Concept générique ↑ nef
Concept spécifique ↓
Concept associé ↔

Relation personnalisée
Traduction AF
++ Notes ⚙️
Définition portion de la nef de Notre-Dame

Ressources externes
Image
Coordonnées GPS

Alignement
Notation

ID Interne @ 44200
Uri @ <https://ark.notre-dame.science/ark:/35572/ndp2pw40vhpcx4jtrc05cft>
ID Ark 35572/ndp2pw40vhpcx4jtrc05cft

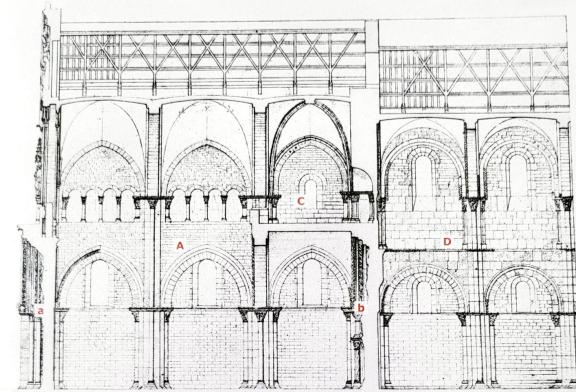
A QR code is located in the bottom right corner of the main panel.

Specific Place and Generic Place (Type)

Nave of Notre-Dame de Paris
(specific instance of place)

Is an instance of the type

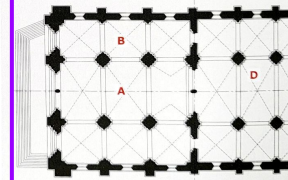
Nef (generic concept)
definition Pérouse de Montclos
(Architectural theory)



882 et 883.
A, C Avant-nef à trois vaisseaux de trois travées.
A Vaisseau central d'avant-nef.
B Bas-côté de l'avant-nef.
C Tribune de l'avant-nef.
D Nef.
a Portail.
b Portail intérieur.
Église de l'abbatiale, Vézelay (Yonne). Relevés d'Anatole de Baudot et d'Anatole Perrault-Dabot, 1898. Paris, Archives des Monuments historiques.

NEF n.f.

Partie d'une église de plan allongé comprise entre l'entrée et le chœur, éventuellement l'avant-chœur ou la croisée du transept. Cette partie de l'église est ouverte aux fidèles. Le chœur liturgique s'étend quelquefois sur les dernières travées de la nef. La nef comprend souvent plusieurs vaisseaux et des chapelles latérales. Nef à trois vaisseaux. Le massif, dans lequel se trouvent souvent les premières travées du vaisseau central, ne fait pas partie de la nef. Ne pas confondre nef et vaisseau.



Références : D'Aviler, Berty. Désigne habituellement le vaisseau (Viollet-le-Duc) ; plus particulièrement le vaisseau central par opposition aux collatéraux (B.M., 1913, p. 282 et suiv.). Mais cette définition, qui devrait conduire à parler des nefes ou de la nef du chœur, est incompatible avec l'opposition également traditionnelle entre nef et chœur.

883.

Fonds de plan : agence Benjamin Mouton, ACMH

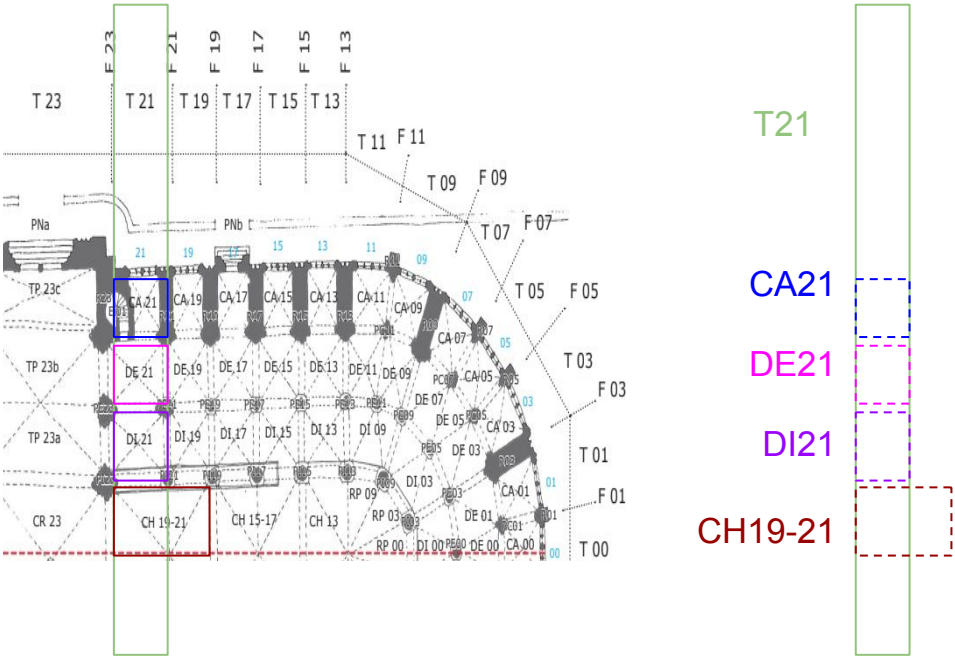
CA Chapelle
CI Collatéral int.
CE Collatéral ext.
CH Chœur
CR Croisée

DI Déambulatoire int.
DE Déambulatoire ext.
EI Escalier intérieur
F File
FO Façade ouest
NC Narthex central
NE Narthex nord
NS Narthex sud
NF Nef
PN Portail nord
PO Portail ouest
PS Portail sud
PA Pile chapelle
PI Pile intérieure
PE Pile extérieure

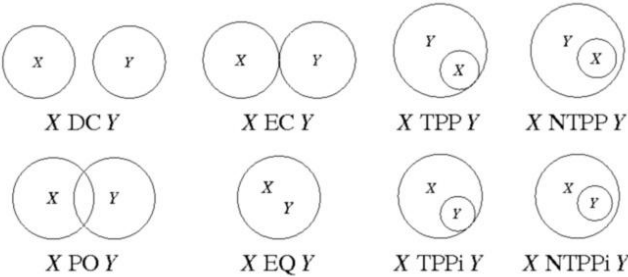
CATHÉDRALE NOTRE-DAME DE PARIS
NOMENCLATURE DES ESPACES
Plan de rez-de-chaussée

ECHELLE 1/500
DATE 23.04.2019
COVALENCE architectes

Correspondances and complex spatial relations between objects/spaces/places and primitives

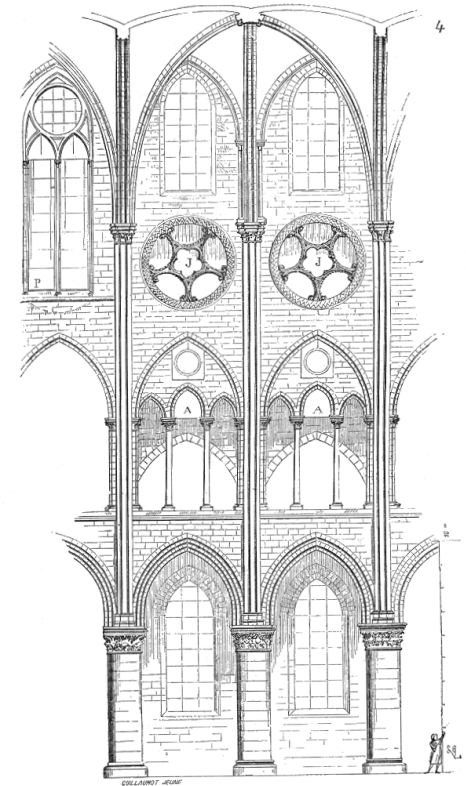
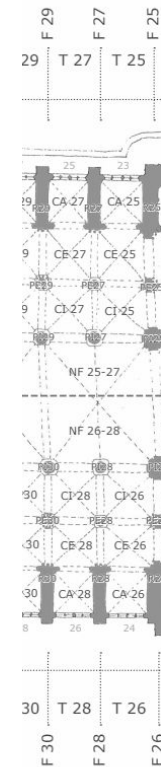


RCC8: topological model



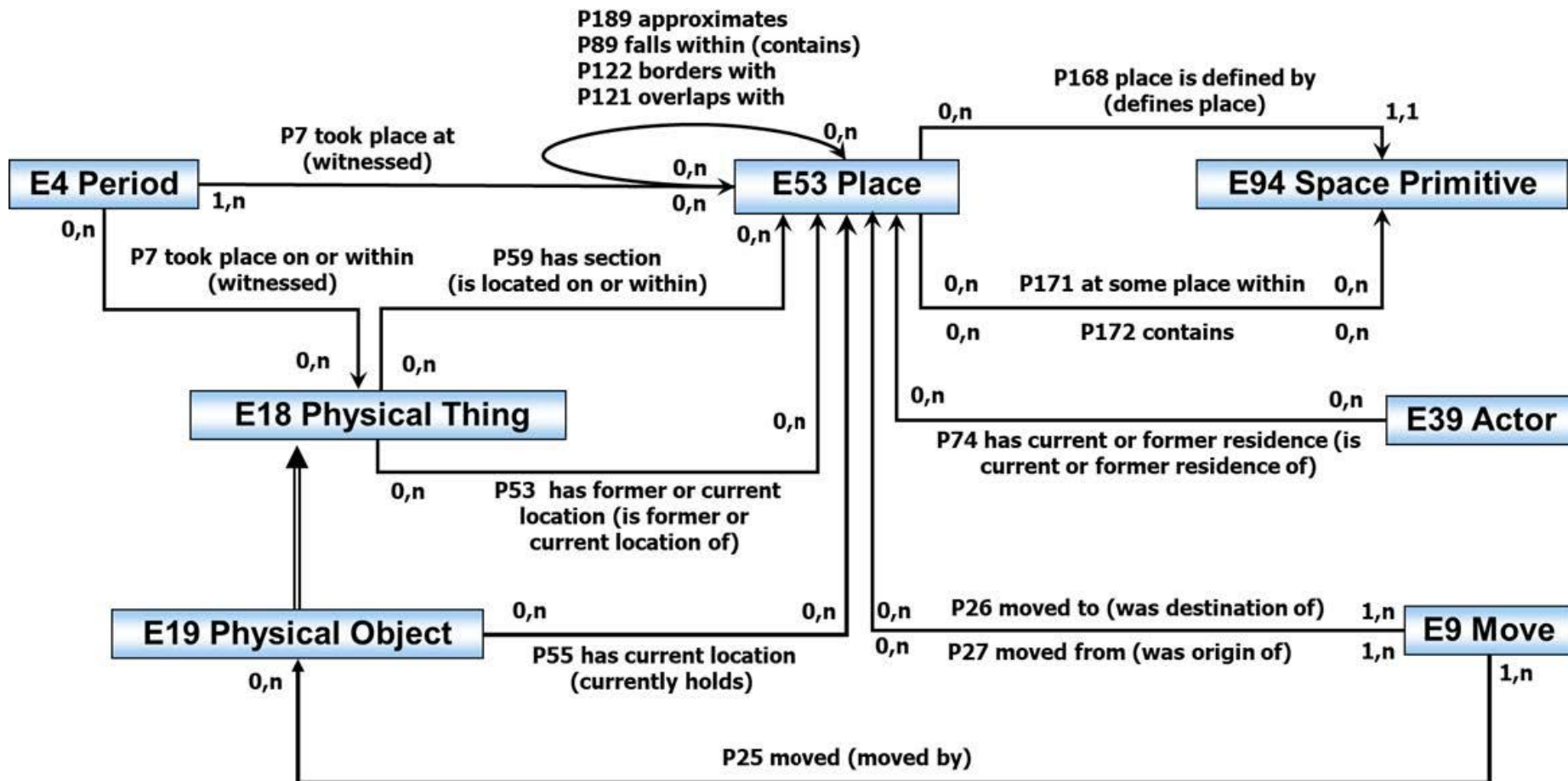
Knauff, M., Rauh, R. and Renz, J. (1997) *A Cognitive Assessment of Topological Spatial Relations: Results from an Empirical Investigation.*, *Proceedings of the International Conference on Spatial Information Theory: A Theoretical Basis for GIS*, p. 206. Available at: https://doi.org/10.1007/3-540-63623-4_51.

Correspondances and complex spatial relations in tridimensional space between objects/spaces/places and primitives



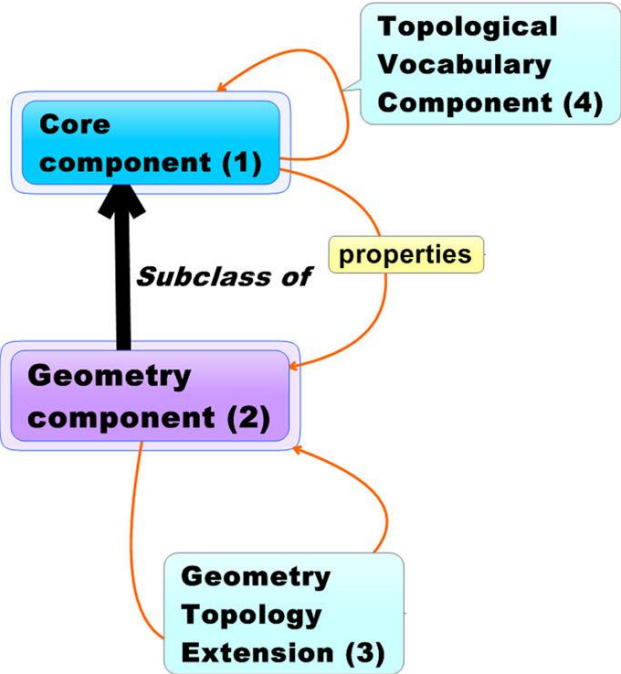
@ (1) Alexis Komenda/C2RM (2) RNDP (3) E.Viollet le Duc

Spatial Relations in CIDOC CRM (v.7.1.2)

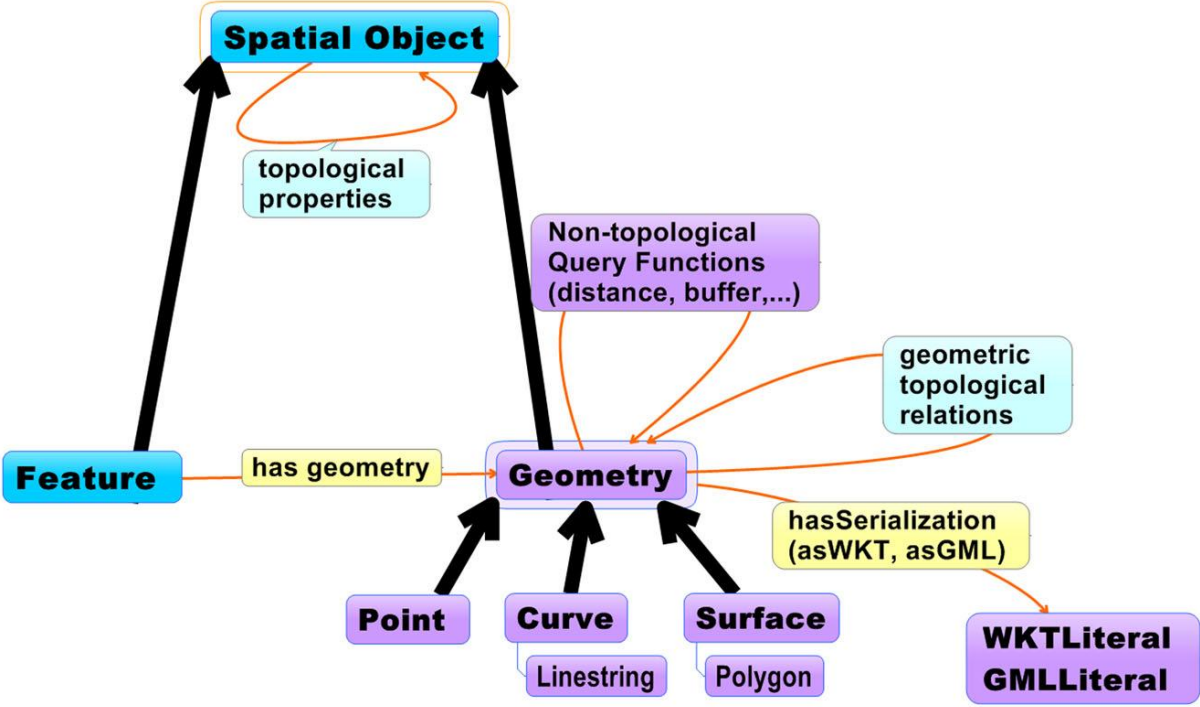


Extended Spatial Relations with CRMgeo/GeoSPARQL

Components

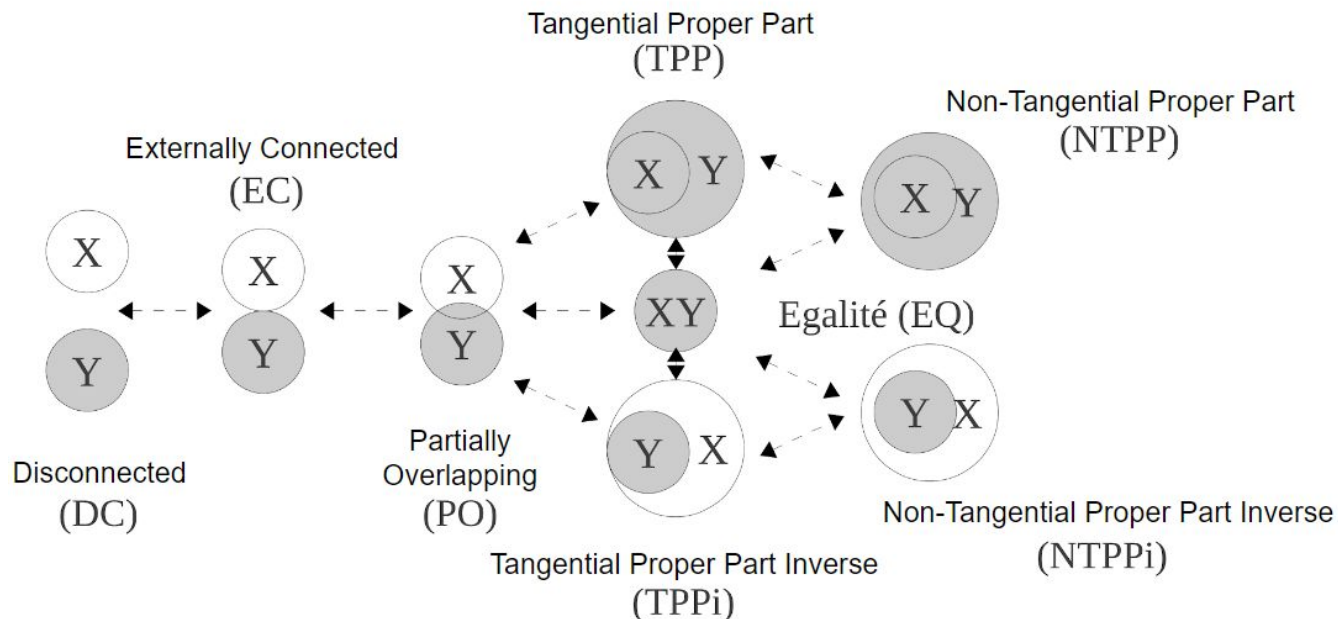


Classes and properties



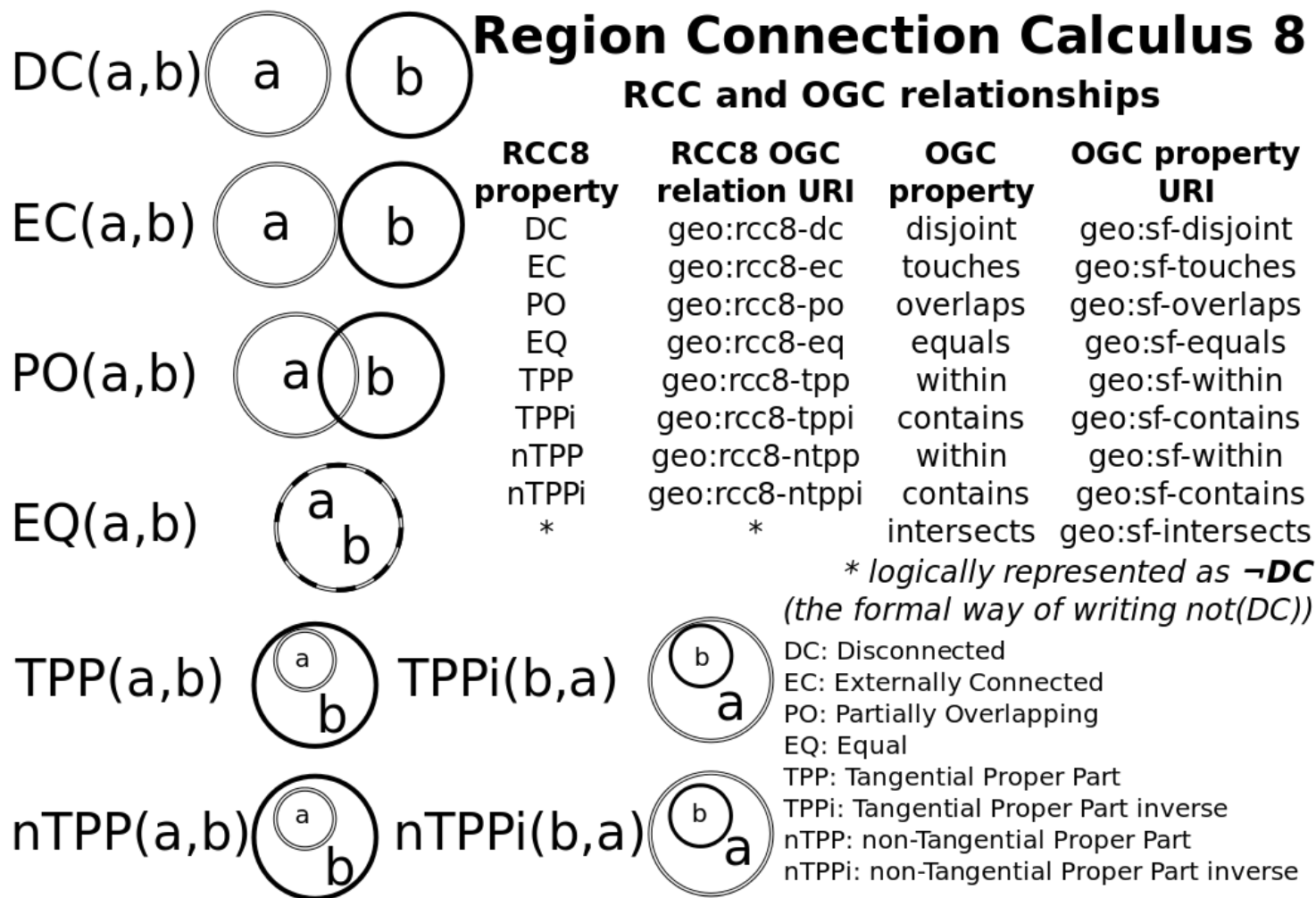
RCC8 Model

Symbol	Name	Note
DC	Disconnected	The two regions are completely disconnected (there are no common pieces)
EC	Externally Connected	The boundaries of the regions touch, but their interiors are disjoint
PO	Partially Overlapping	The two regions partially overlap (there are disjoint sub parts, and some part of one is included in some part of the other)
EQ	EQual	Two regions have the same spatial extent
TPP	Tangential Proper Part	The first region is entirely inside the second region and their boundaries touch each other from the inside
TPPi	Tangential Proper Part Inverse	The first region contains the second region and their boundaries touch each other from the inside
NTPP	Non-Tangential Proper Part	The first region is entirely inside the second region and their boundaries do not touch
NTPPi	Non-Tangential Proper Part Inverse	The first region contains the second region and their boundaries do not touch



Implementation of RCC8 in Geosparql:

<http://www.opengis.net/def/function/geosparql>



RCC8xCRM:

Analysis of topological relation expression in CIDOC CRM

Table 2

Analysis of the CIDOC CRM properties against the RCC8 relations: we check whether the CIDOC CRM properties express some topological relationships. We specify if the topology is rather defined in (a) the scope note, (b) the examples or if it is (c) unspecified.

Domain	Property label	Range	DC	EC	PO	EQ	TPP	TPPi	nTPP	nTPPi
E18	P53 has current or former location	E53				x(a)	x(b)		x(b)	
E18	P59 has section	E53						x		x
E18	P156 occupies	E53				x(a)				
E18	P157i provides reference space for	E53	x	x	x	x	x	x	x	x
E19	P55 has current location	E53				x(a)	x(b)		x(b)	
E53	P53i is former or current location of	E18				x(a)		x(b)		x(b)
E53	P55i currently holds	E19				x(a)		x(b)		x(b)
E53	P59i is located on or within	E18					x		x	
E53	P89 falls within	E53					x		x	
E53	P89i contains	E53						x		x
E53	P121 overlaps with	E53			x	x(c)	x(c)	x(c)	x(c)	x(c)
E53	P122 borders with	E53		x			x	x		
E53	P156i is occupied by	E18				x		x		x
E53	P157 is at rest relative to	E18	x	x	x	x	x	x	x	x
E53	P168 place is defined by	E94				x		x(a)		x(a)
E53	P171 at some place within	E94				x	x		x	
E53	P172 contains	E94				x		x		x
E53	P189 approximates	E53	x	x	x	x	x	x	x	x
E92	P10 falls within	E92				x	x		x	
E92	P10i contains	E92				x		x		x
E92	P132 spatiotemporally overlaps with	E92			x	x(c)	x(c)	x(c)	x(c)	x(c)
E92	P133 spatiotemporally separated from	E92	x							
E94	P168i defines place	E53				x	x(a)		x	

Using RCC8 for non-geometrical entities

The RCC8 formalism defines eight elementary relationships [Figure 5] to describe spatial relations between entities whose primitives are regions [Table 1]. [27] state that RCC8 formalism is dimension independent, applicable in \mathbb{R}^n , and then demonstrate each of the axioms and subsequent theorems: “The language RCC8 is a widely-studied formalism for describing topological arrangements of spatial regions. The variables of this language range over the collection of non-empty, regular closed sets of n-dimensional Euclidean space, here denoted $(RC + \mathbb{R}^n)$, and its non-logical primitives allow us to specify how the interiors, exteriors and boundaries of these sets intersect” [27, 28]. However, the RCC system does not distinguish between open and closed geometries. Conceptually, human thought is capable of manipulating abstract notions of openness, such as the interior of a room, a building, etc. [29]. Moreover.

[29] Y. Larvor, Notions de méréogéométrie: description qualitative de propriétés géométriques du mouvement et de la forme d’objets tridimensionnels, Ph.D. thesis

Searching for foundational relations

Danash & Ziebelin's article aims at developing foundational relations [FR] (FORT: Foundational Ontological Relations Theory) in relation to the most known foundational ontologies (FOs). Some types of FRs: parthood, dependance, constitution, membership, location. Analysis of FORT in regards to existing FOs: BFO, DOLCE, UFO in order to position and align it with these different FOs.

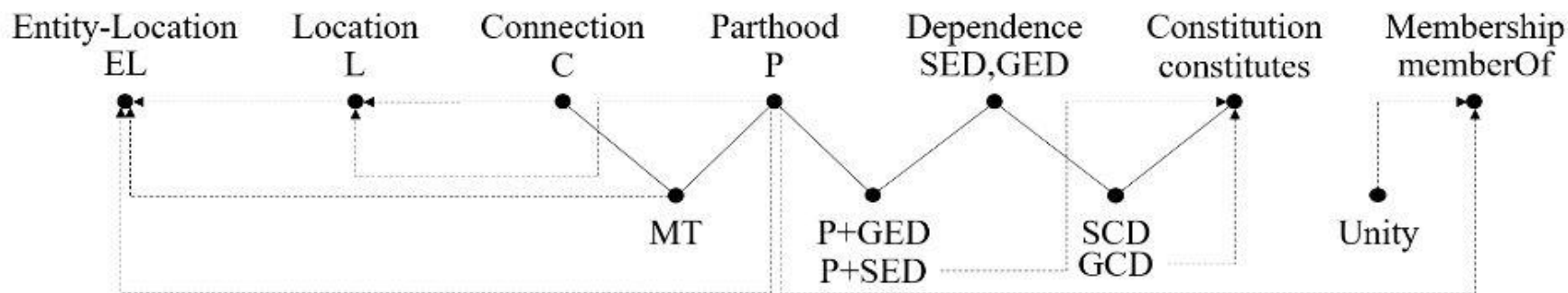


Figure 1: FORT's relation modules, their interlinks (plain lines) and participation, as axioms in the formalization of other relations (dotted lines).

Danash, F. and Ziébelin, D. (2022) 'On the Analysis of FORT; arguments, alignment to FOs, and CLIF validation', in *The 6th Workshop on Foundational Ontology (FOUST), @ The Joint Ontology Workshops (JOWO'2022)*.

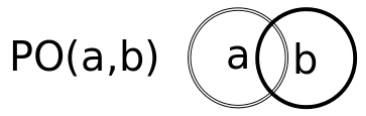
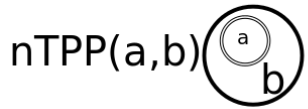
Modeling rationale: non-geometric (yet spatial) topological relations

It aims at the knowledge representation of the complex spatial relations in heterogeneous cultural built heritage data **systematically expressed**. The contribution presents the conceptual modeling of these topological relations using both the **CIDOC CRM (with its extension CRMgeo) and the RCC8**.

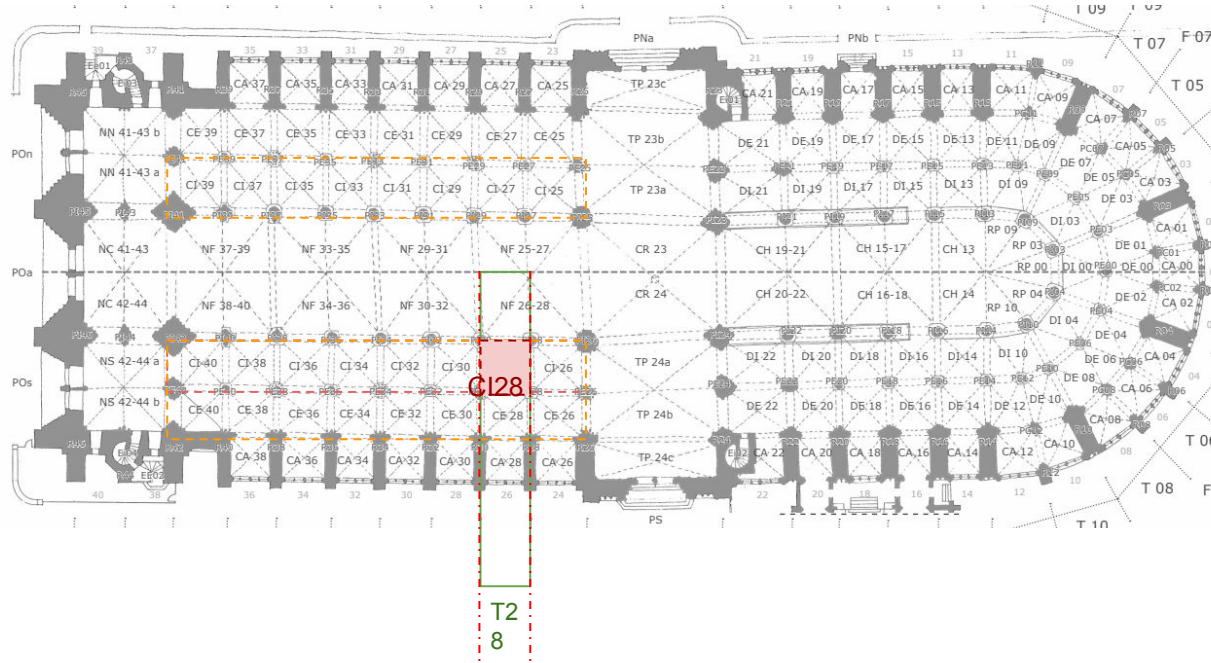
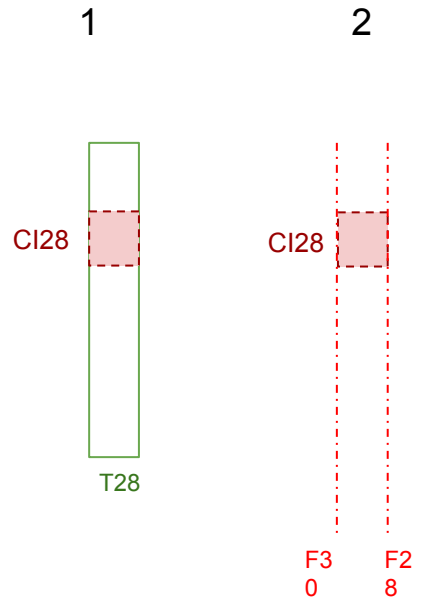
From the scope of the CIDOC CRM, this modeling is constructed as the interface between RCC8 and CRM to allow the expression of the needed **abstract topological relations**. This work is thought in **analogy with existing modeling**:

- firstly, in the CIDOC CRM model, the entity `crm:E55_Type` acts as a bridge to SKOS where the thesauri are externally managed. Similarly, the objective is here to investigate the compatibility between CIDOC CRM and RCC8 models.
- Secondly, the modeling of time properties is explicitly inspired from Allen principles: we propose to apply a similar perspective for the question of spatial relations. In brief, we posit that the RCC8 can play the role of a semantic module for the topological relationships, in combination with the CIDOC CRM as domain ontology for the integration of heterogeneous CH data.

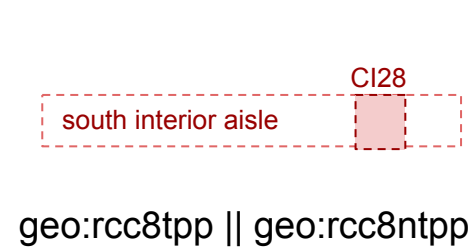
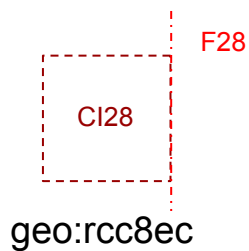
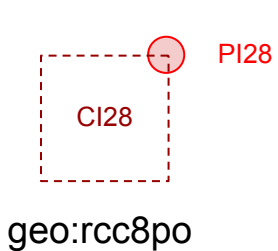
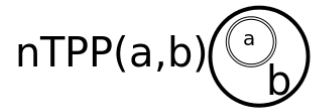
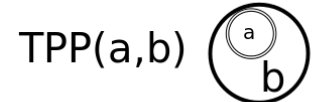
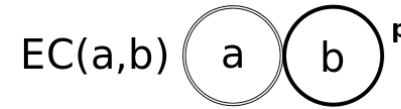
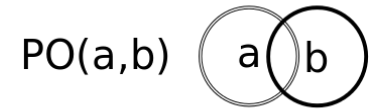
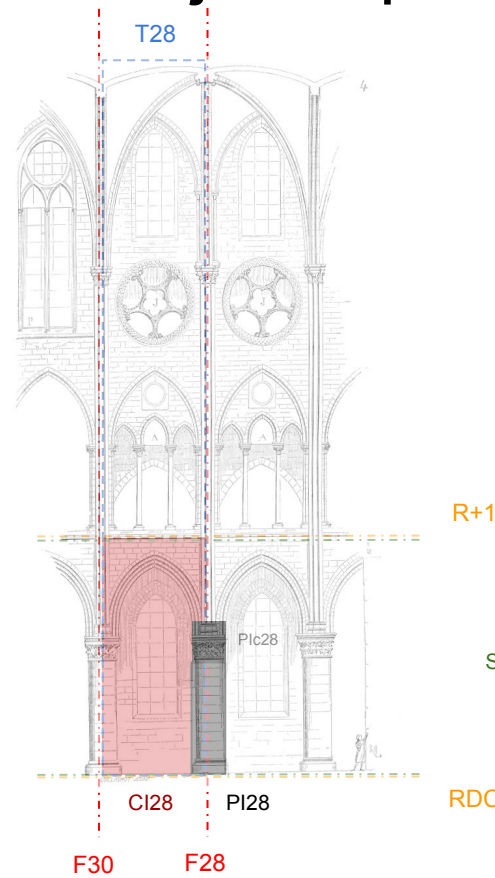
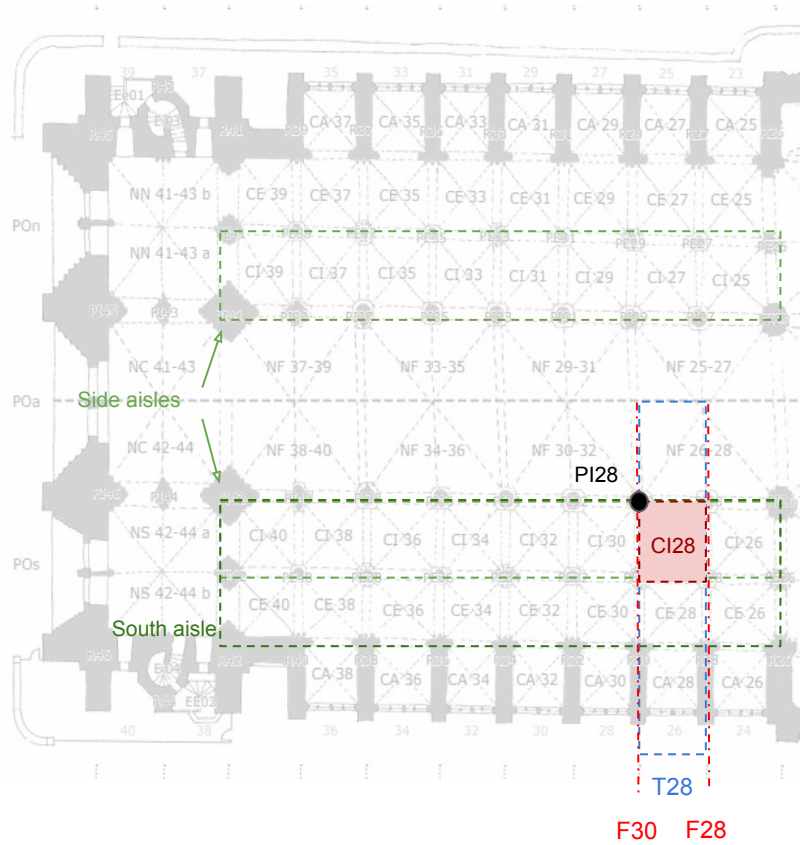
Topological Relation: Place - Spatial Primitive



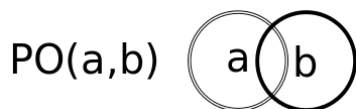
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CI28 <geo:rcc8-nttp> T28
- 2:
CI28 <geo:rcc8-po> F28
CI28 <geo:rcc8-po> F30



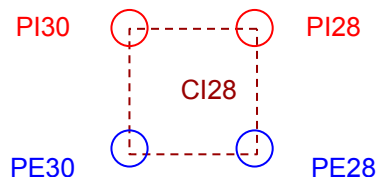
Topological Relation: Place - Object/Spatial Primitive



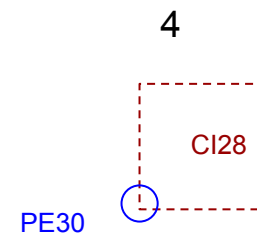
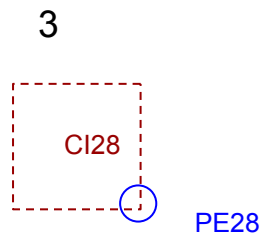
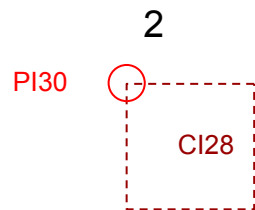
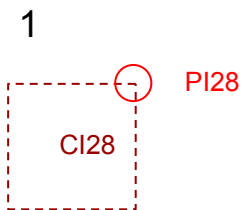
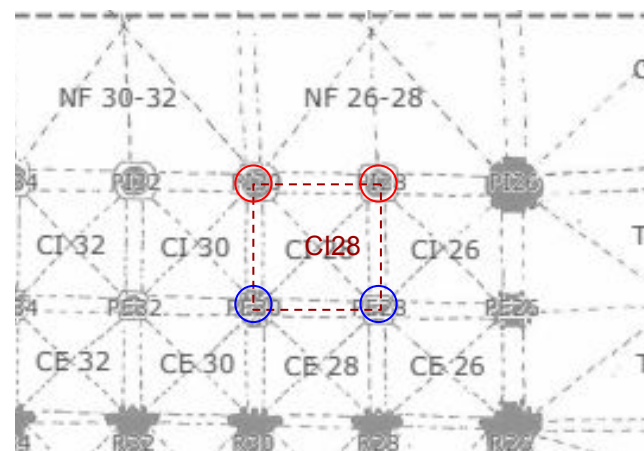
Topological Relation: Place - Object



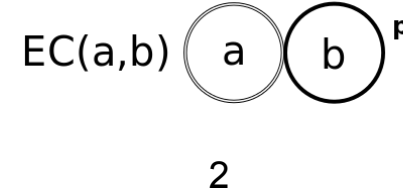
- 1:
CI28 geo:rcc8-po PI28
- 2:
CI28 geo:rcc8-po PI30
- 3:
CI28 geo:rcc8-po PE28
- 4:
CI28 geo:rcc8-po PE30



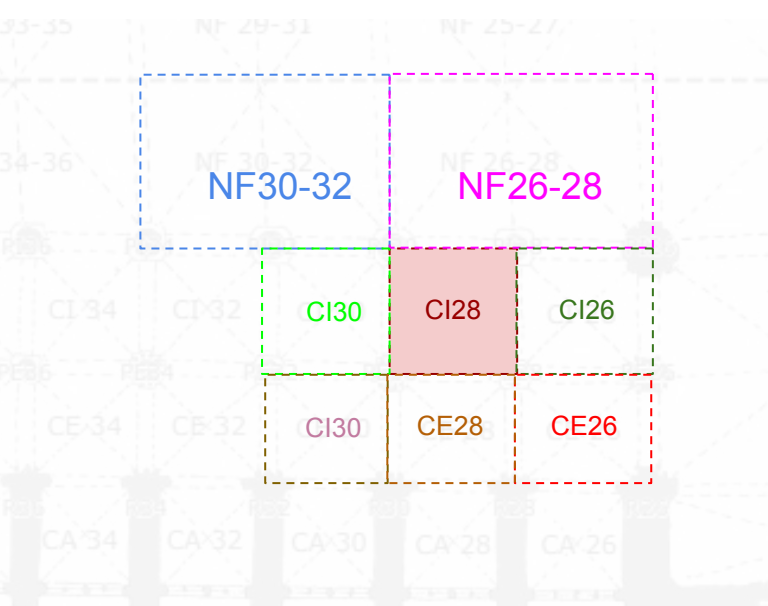
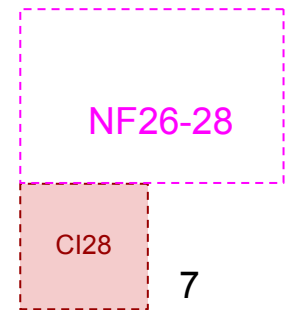
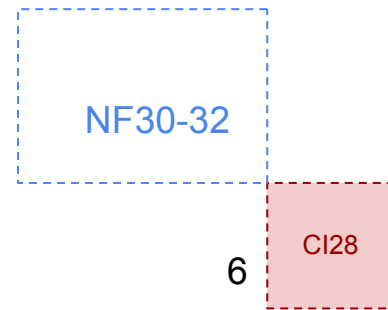
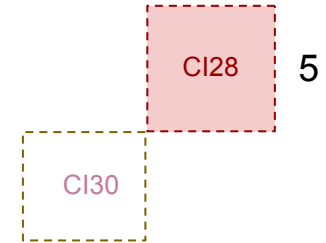
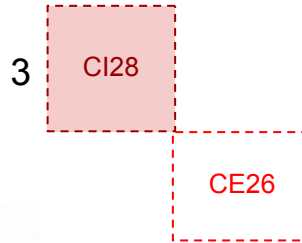
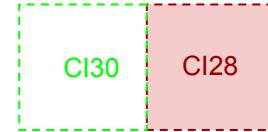
PE*= pile extérieure
PI*= pile intérieure



Topological Relation: Place - Place



- 1: CI28 geo:rcc8-ec CI30
- 2: CI28 geo:rcc8-ec CI26
- 3: CI28 geo:rcc8-ec CE26
- 4: CI28 geo:rcc8-ec CE28
- 5: CI28 geo:rcc8-ec CE30
- 6: CI28 geo:rcc8-ec NF30-32
- 7: CI28 geo:rcc8-ec NF26-28

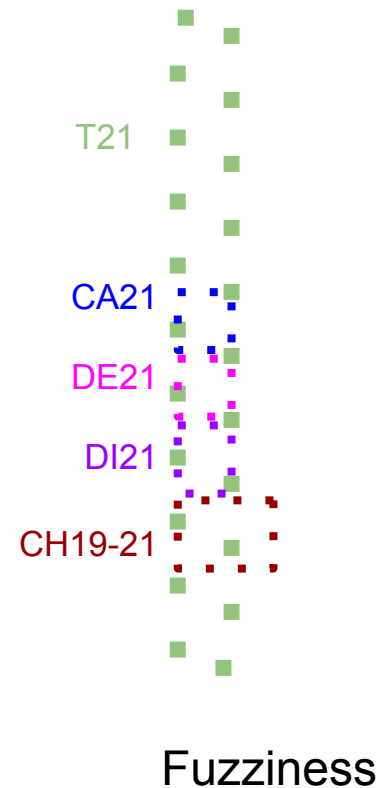


Conclusion

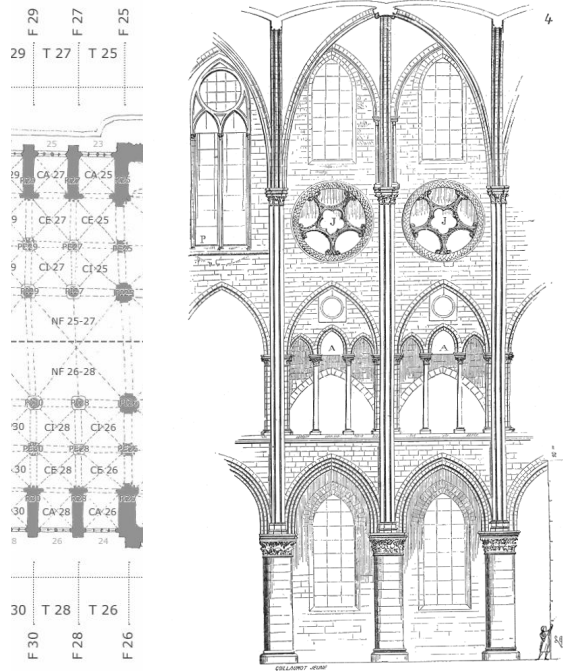
- Geometry and geographical data are representations of space among others
- Space and place are different things
- Topological relationship (RCC8+CIDOC CRM) can be applied on non-geometric spatial data and more consistently than the existing CIDOC CRM properties

Future Work

- Complex spatial indexing/query/reasoning on data (implementation tests)
- New issue for the CIDOC CRM SIG about the modeling of topological relations in CRM
- Anthropological definition of space (ontological modeling)
- Fuzziness aspect in topological relation (ontological modeling)



Reconstruction beyond Representation in Notre-Dame de Paris



Acknowledgements:

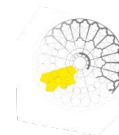
E-RIHS project
Astragale project
Repérage project
ERC NDame_Heritage project
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*RCC8 for CIDOC CRM: semantic modeling of mereological
and topological spatial relations in Notre-Dame de Paris
A.Guillem, A.Gros, K.Reby ; V.Abergel, L.De Luca ;
SWODCH 2023, Athens*



ndame

écosystème pour l'analyse et la mémorisation multi-dimensionnelle du chantier
scientifique de Notre-Dame de Paris



