3. Fachgespräch »Ortsbezogene Anwendungen und Dienste«

Modeling Context Constraints

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Outline

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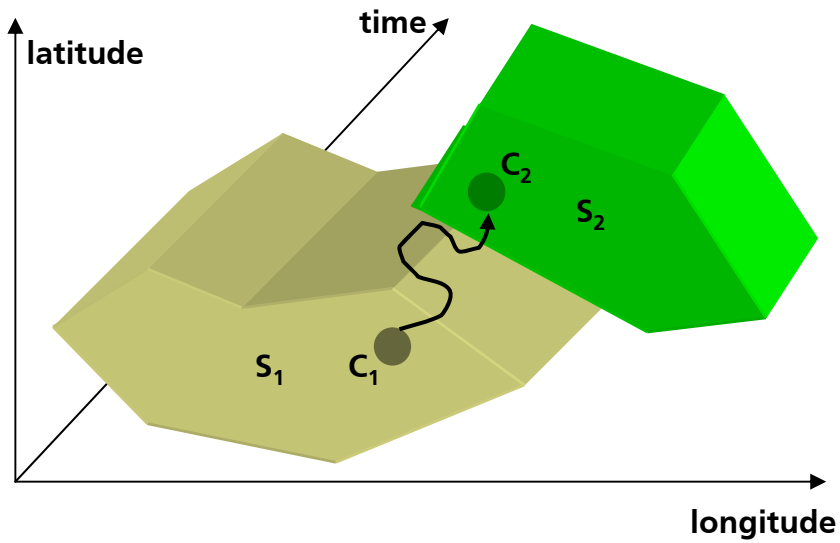
Need for Defining Context Constraints: Service Roaming



Services often have limited scope

Users (especially mobile users) change their contexts frequently

Services are valid for a certain user if user context is within service scope

Whenever the context leaves the scope service roaming is needed

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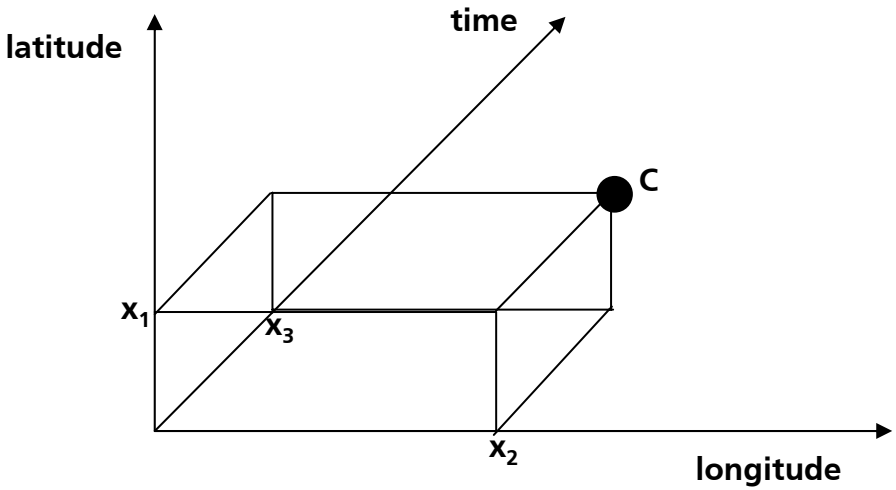
Context



Defined by values of n context dimensions

Represented by an n-tuple

In this example: 3 dimensions

C=(latitude, longitude, time)

Certain value for each context dimension

Single point in context hyperspace

Current context values of an entity (a user)

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Context Hyperspace

Characteristics	Cartesian n-dimensional space
	Dimensions defined for [-∞; ∞]
	Dimensions defined on ℝ
Context attributes	Often limited range (e. g. longitude [-180;180])
	Not always defined on ℝ (e. g. room numbers)
	Not always numbered (e. g. weather: cloudy)
	Not always distinct (e. g. language capabilities: DE, EN)

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Scales of Measurement, Scale of Representation

Scales of measurement

- Nominal
  Equal or unequal (e. g. male, female)

- Ordinal
  Nominal + order of values (e. g. room numbers)

- Interval
  Ordinal + definite difference (e. g. temperature)

- Proportional / rational
  Interval + natural zero point (e. g. length)

Scale of representation

- Always proportional scale (because defined on $\mathbb{R}$)

Transformation

Context attributes

For each context attribute c_i there has to be a transformation into the representation attribute d_i

$$\forall c_i : \exists f(c_i) \rightarrow d_i; d_i \in I\!R$$

This transformation is injective
(For each input value there is a distinct output value)

Context semantics

Context may constist of more than name/value pairs

Semantics are seperated from values (semantic layer)

Semantic layer

Contains scale of origin, relationships between context dimensions, ... (Not necessary for service roaming!)

Context Representation

Operations

Proportional scale allows many operations (Order, difference, ratio, ...)

Only check for equality is needed for service roaming
=> Only this is allowed on the context representation per default

All other operations are supported only if allowed by the semantic layer

Integrity

$$op(f(c_i)) = f(op(c_i))$$

Reverse transformation

Leads to initial context value

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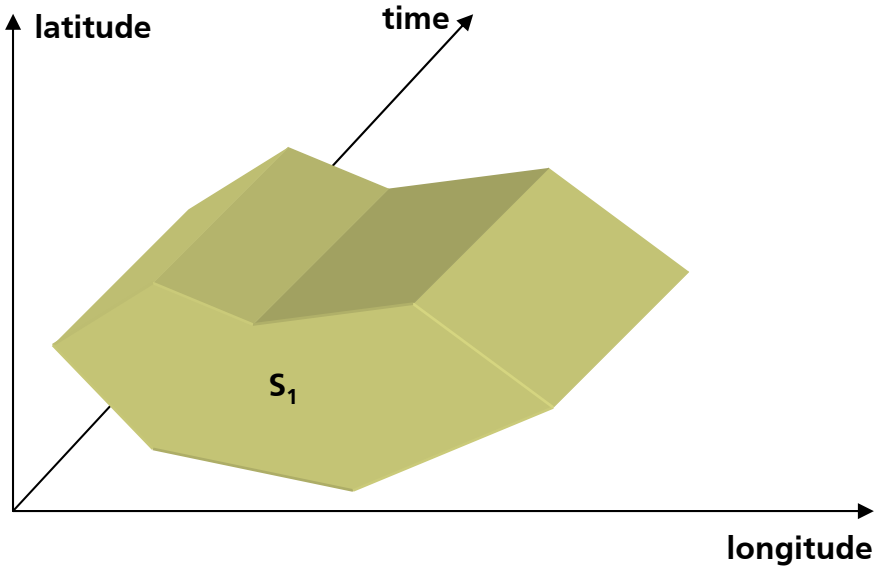
Service Scope Representation



Service scope: n-dimensional polytope
(Assumption of linearity for simplification)

Two (popular) ways of representation:

- Boundary representation
  Each n-dimensional object is recursively described by its (n-1)-dimensional boundaries

- Constraint representation
  Systems of linear inequations, each of them defining a half-hyperspace

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Comparison of Representations

Boundary

Very popular in Solid Modeling

Used in GIS for representation of 2D/3D objects

Very verbose for n-dimensional objects (for large n's)

$b_n \geq \prod_{i=1}^{n} i+1$ (b_n: number of bounding objects)

Constraint

Only capable to describe convex objects

Less computation for ‚INCLUDES' operator

Easier to convert boundary representation to constraint representation than other way round

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Decision: Constraint Representation

Reasons

Verbosity of boundary representation is major criteria

Many restrictions are already initially
in constraint representation (e. g. time $\geq$ 8:00)

Only few restrictions are initially in boundary representation (e. g. spatial restrictions by polygons)

Non-convex scopes

Each non-convex polytope can be decomposed into a set of convex polytopes.

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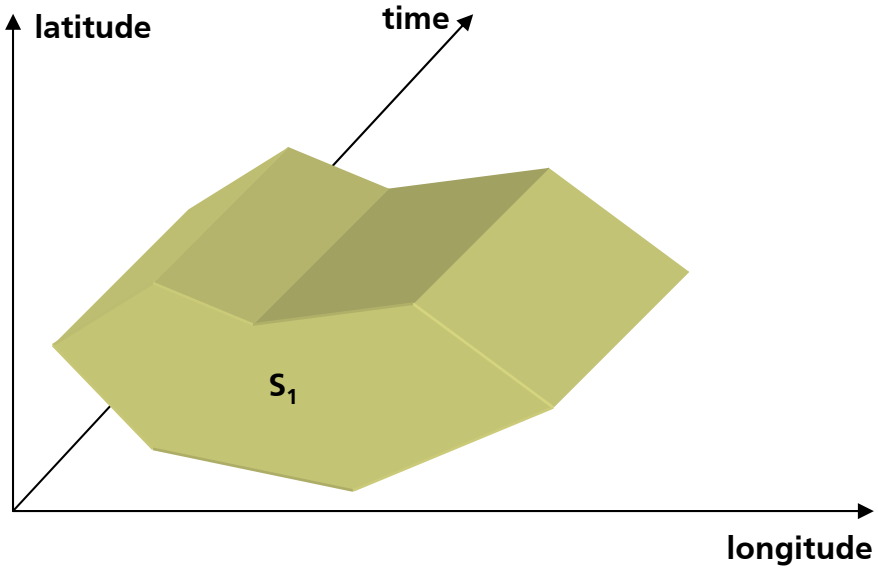
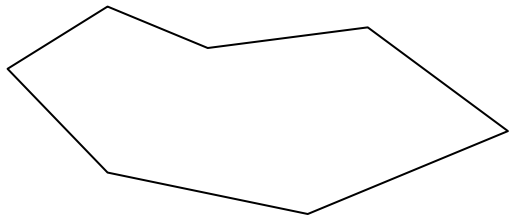
Example



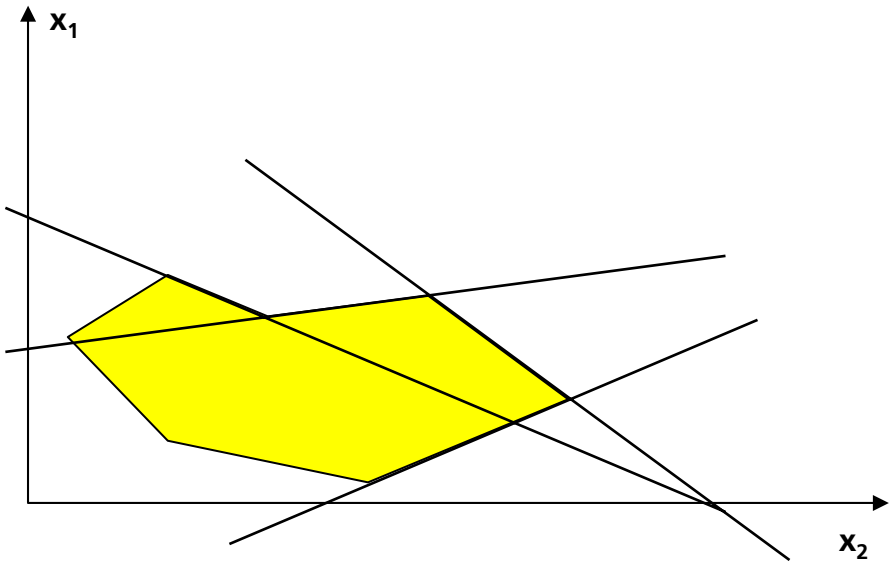
Constraints:

Time: between 8:00 and 21:00

Space: Within the following polygon



Spatial Dimensions



1. $x_1=-x_2+1,4$
2. $x_1=-0,125x_2+0,6$
3. $x_1=0,4x_2-0,9$
4. $x_1=-0,75x_2+3,6$
5. $x_1=0,16x_2+1$
6. $x_1=-0,4x_2+2$
7. $x_1=0,6x_2+1$

$x_1 \geq -x_2+1,4$	$\Leftrightarrow -x_1-x_2+1,4 \leq 0$	(1)
$x_1 \geq -0,125x_2+0,6$	$\Leftrightarrow -x_1-0,125x_2+0,6 \leq 0$	(2)
$x_1 \geq 0,4x_2-0,9$	$\Leftrightarrow -x_1+0,4x_2-0,9 \leq 0$	(3)
$x_1 \leq -0,4x_2+2$	$\Leftrightarrow x_1+0,4x_2-2 \leq 0$	(6)
$x_1 \leq 0,59x_2+1$	$\Leftrightarrow x_1-0,59x_2-1 \leq 0$	(7)
$x_1 \geq 0,4x_2-0,9$	$\Leftrightarrow -x_1+0,4x_2-0,9 \leq 0$	(3)
$x_1 \leq -0,75x_2+3,6$	$\Leftrightarrow x_1+0,75x_2-3,6 \leq 0$	(4)
$x_1 \leq 0,16x_2+1$	$\Leftrightarrow x_1-0,16x_2-1 \leq 0$	(5)
$x_1 \geq -0,4x_2+2$	$\Leftrightarrow -x_1-0,4x_2+2 \leq 0$	(6)

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Time Dimension

Restriction Daily from 8:00 to 21:00

Transformation daytime

$$d_{time} = f(c_{time}) = hours(c_{time})*60 + minutes(c_{time})$$
$$c_{time} = 8:00 \Rightarrow d_{time} = 480$$
$$c_{time} = 21:00 \Rightarrow d_{time} = 1260$$

Constraints

$$x_3 \geq 480 \quad \Leftrightarrow -x_3 + 480 \leq 0$$
$$x_3 \leq 1260 \quad \Leftrightarrow x_3 - 1260 \leq 0$$

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Matrix Representation of Service Scope

Spatial Restrictions

$-x_1-x_2+1{,}4\leq 0$
$-x_1-0{,}125x_2+0{,}6\leq 0$
$-x_1+0{,}4x_2-0{,}9\leq 0$
$x_1+0{,}4x_2-2\leq 0$
$x_1-0{,}59x_2-1\leq 0$

$-x_1+0{,}4x_2-0{,}9\leq 0$
$x_1+0{,}75x_2-3{,}6\leq 0$
$x_1-0{,}16x_2-1\leq 0$
$-x_1-0{,}4x_2+2\leq 0$

Time Restriction

$-x_3+480\leq 0$
$x_3-1260\leq 0$

Matrices

$$\begin{pmatrix} -1 & -1 & 0 & 1{,}4 \\ -1 & -0{,}125 & 0 & 0{,}6 \\ -1 & 0{,}4 & 0 & -0{,}9 \\ 1 & 0{,}4 & 0 & -2 \\ 1 & -0{,}59 & 0 & -1 \\ 0 & 0 & -1 & 480 \\ 0 & 0 & 1 & -1260 \end{pmatrix} \vee \begin{pmatrix} -1 & 0{,}4 & 0 & -0{,}9 \\ 1 & 0{,}75 & 0 & -3{,}6 \\ 1 & -0{,}16 & 0 & -1 \\ -1 & -0{,}4 & 0 & 2 \\ 0 & 0 & -1 & 480 \\ 0 & 0 & 1 & -1260 \end{pmatrix}$$

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Is Context Within Service Scope?

Definition

Context is within service scope if context is element of the solution set of one of the matrices.

Example

Context (2,9; 1,2; 555)
(lat = 2,9; long = 1,2; time = 9:15)

Result

$(2{,}9;\ 1{,}2;\ 555) \in \mathbb{L}(M_2)$

$\Rightarrow$ Context is within service scope and service is valid!

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Conclusion

Context model	Different context models exist in literature
	Service roaming only needs context data
	Context semantics are seperated in semantic layer
	Context data + semantic layer + transformation functions should maintain all information provided by existing context models
Scope representation	Proposed representation is absolutely generic
	Linear scopes should be sufficient
	Constraint representation is preferable

Thanks for your attention!

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