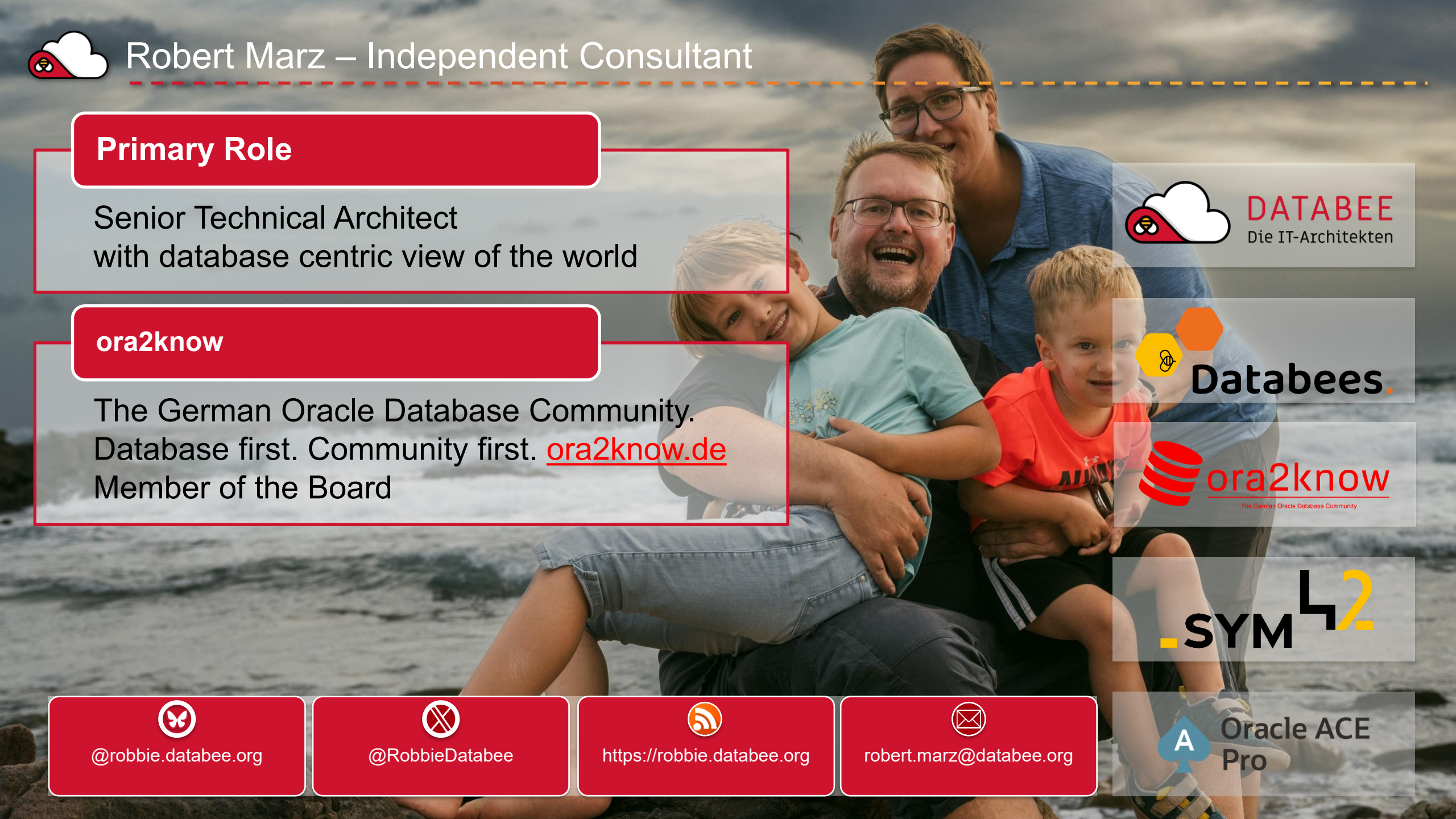
Oracle ~~23ai~~ 26ai:
Domains & Annotations Deep Dive

Dienstag, 09. Dezember 2025 (09:00 - 09:45) | Satellit Ebene 1

Robert Marz
DATABEE
Die IT-Architekten



Robert Marz – Independent Consultant

Primary Role

Senior Technical Architect
with database centric view of the world

ora2know

The German Oracle Database Community.
Database first. Community first. ora2know.de
Member of the Board

DATABEE
Die IT-Architekten

Databees.

ora2know
The German Oracle Database Community

SYMPA2

Oracle ACE Pro

@robbie.databee.org

@RobbieDatabee

https://robbie.databee.org

robert.marz@databee.org

- Eine starke Community für Oracle Datenbank Benutzer
- Ziele: Wissensvermittlung für Entwickler und DBAs
- Angebote: MeetUps, Podcasts, Live Events
- Projekte: Veranstaltung zum Kennenlernen
- Kontakt: info@ora2know.de

ora2know

The German Oracle Database Community

Oracle ACE

The Oracle ACE Program

400+ technical experts helping peers globally

- The Oracle ACE Program recognizes and rewards community members for their technical and community contributions to the Oracle community
- 3 membership levels: Director, Pro, and Associate
- Nominate yourself or a colleague at ace.oracle.com/nominate
- Learn more at ace.oracle.com

aceprogram_ww@oracle.com
Facebook.com/OracleACEs
@oracleace
Oracle ACE Program Group

.SYMPOSIUM 42

Created by the community, to support the community

Sharing of reliable knowledge
Supporting the various user groups and individuals

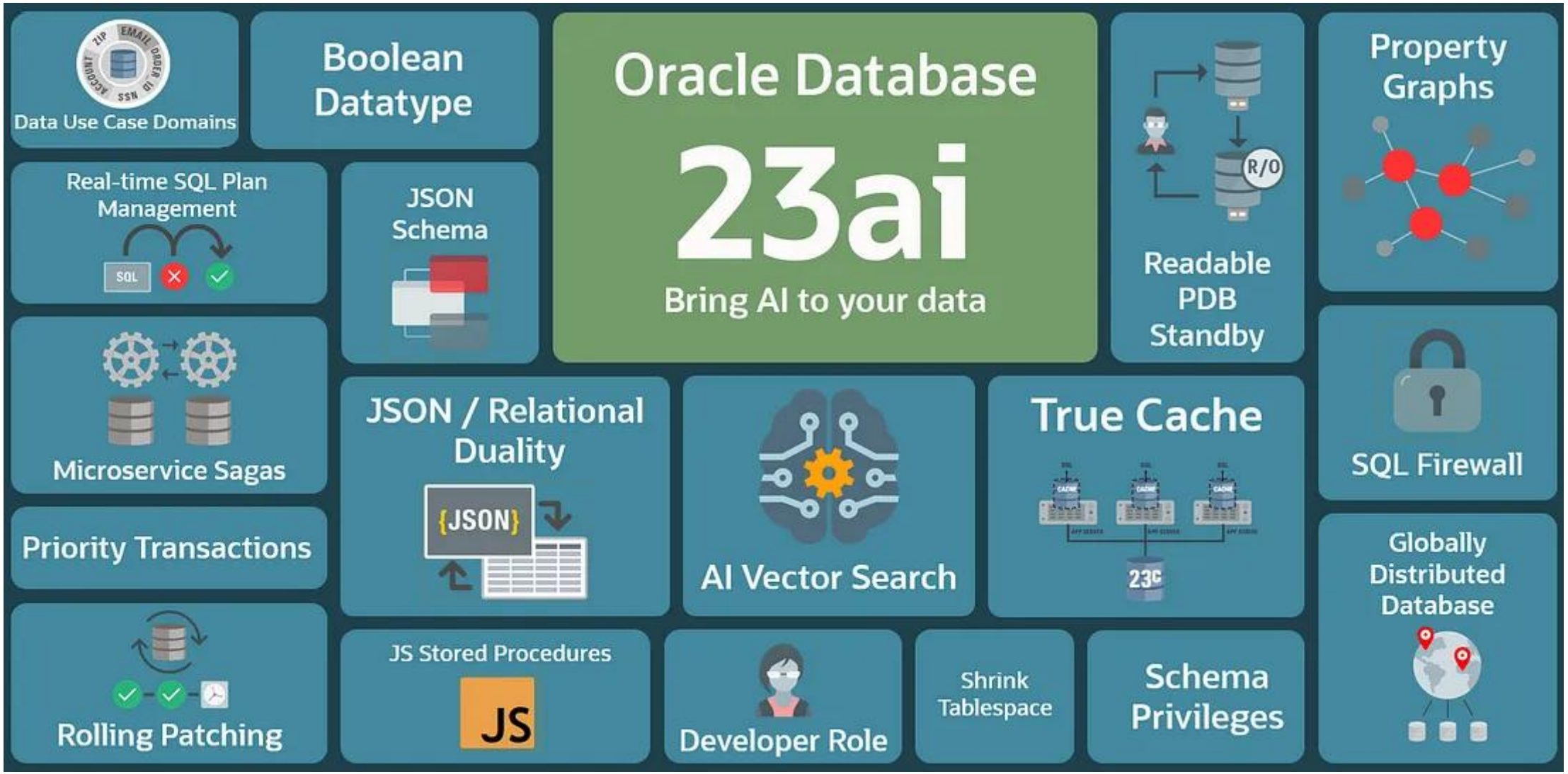
@sym_42

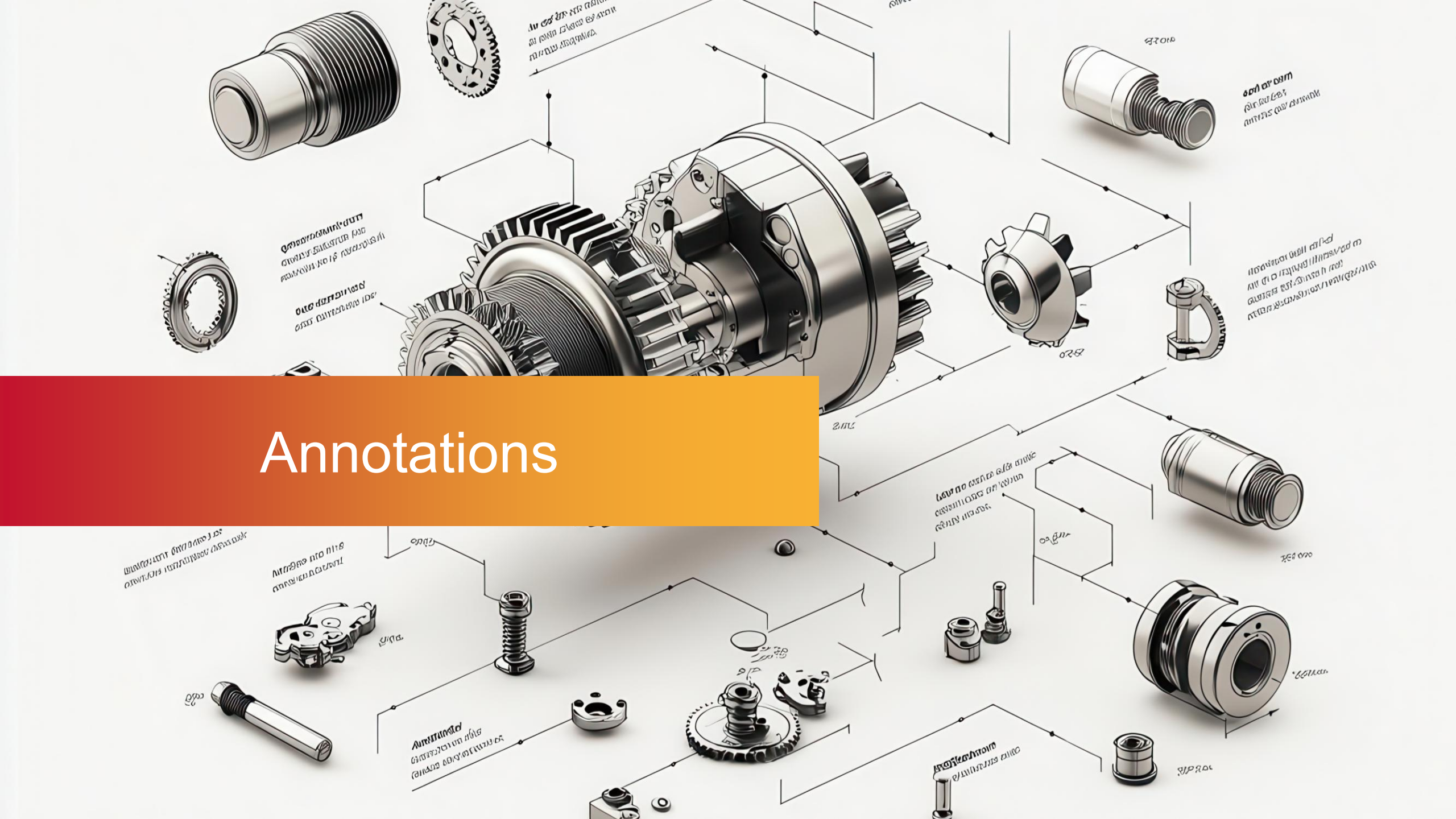
https://sym42.org/

Oracle ACE Pro

Oracle 23ai

Oracle 23ai Feature Overview

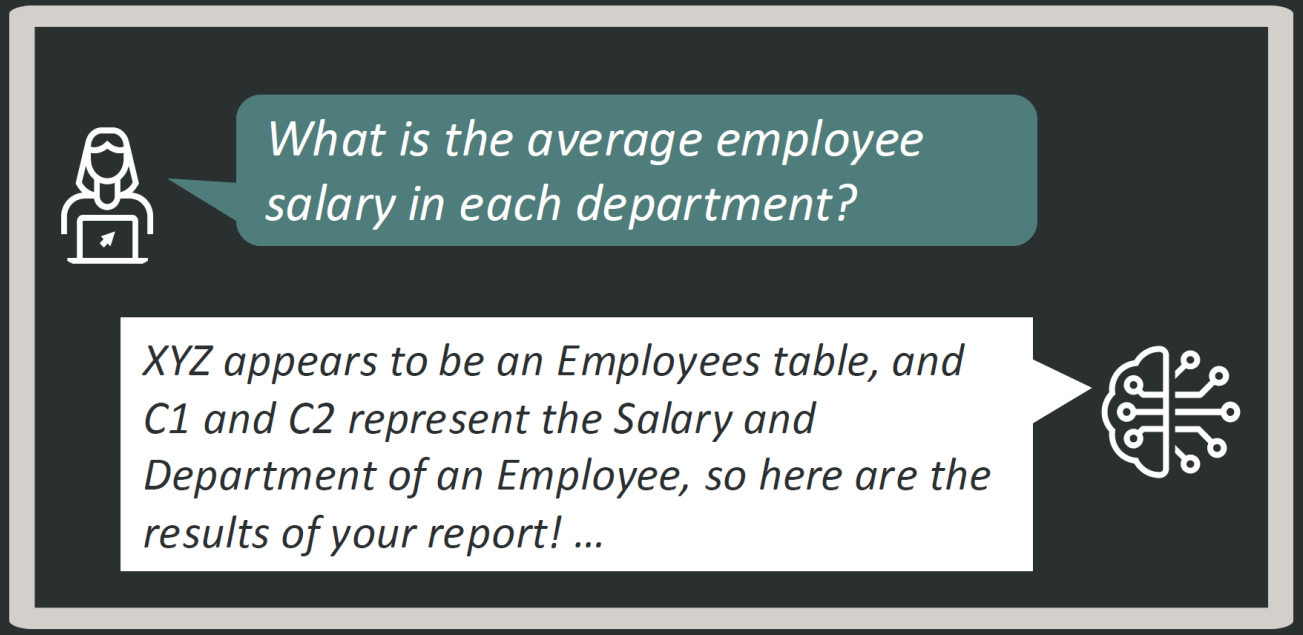




Annotations

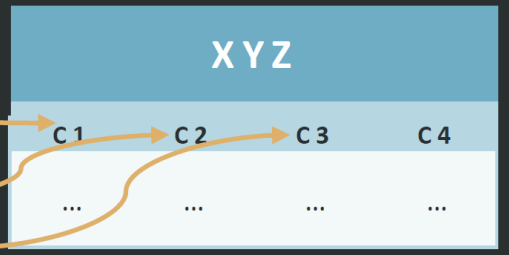
Annotations – Help to explain Data and Semantics to AI

Annotations in 23ai (backported to 19c) enable metadata augmentation with data intent and semantics



XYZ			
C1	C2	C3	C4
…	…	…	…
…	…	…	…
…	…	…	…

```
ALTER TABLE XYZ ANNOTATIONS (ADD Purpose ‘Employee_Detail’);
ALTER TABLE XYZ MODIFY (C1 ANNOTATIONS (Salary ‘USD’));
ALTER TABLE XYZ MODIFY (C2 ANNOTATIONS (Name ‘First & Last’));
ALTER TABLE XYZ MODIFY (C3 ANNOTATIONS (Department ‘Abbreviated’));
```



Annotations – Modern Comments

Comments

Separate Objects

single text line

- per table
- per column

Apply to

- Tables
- Views
- Materialized Views

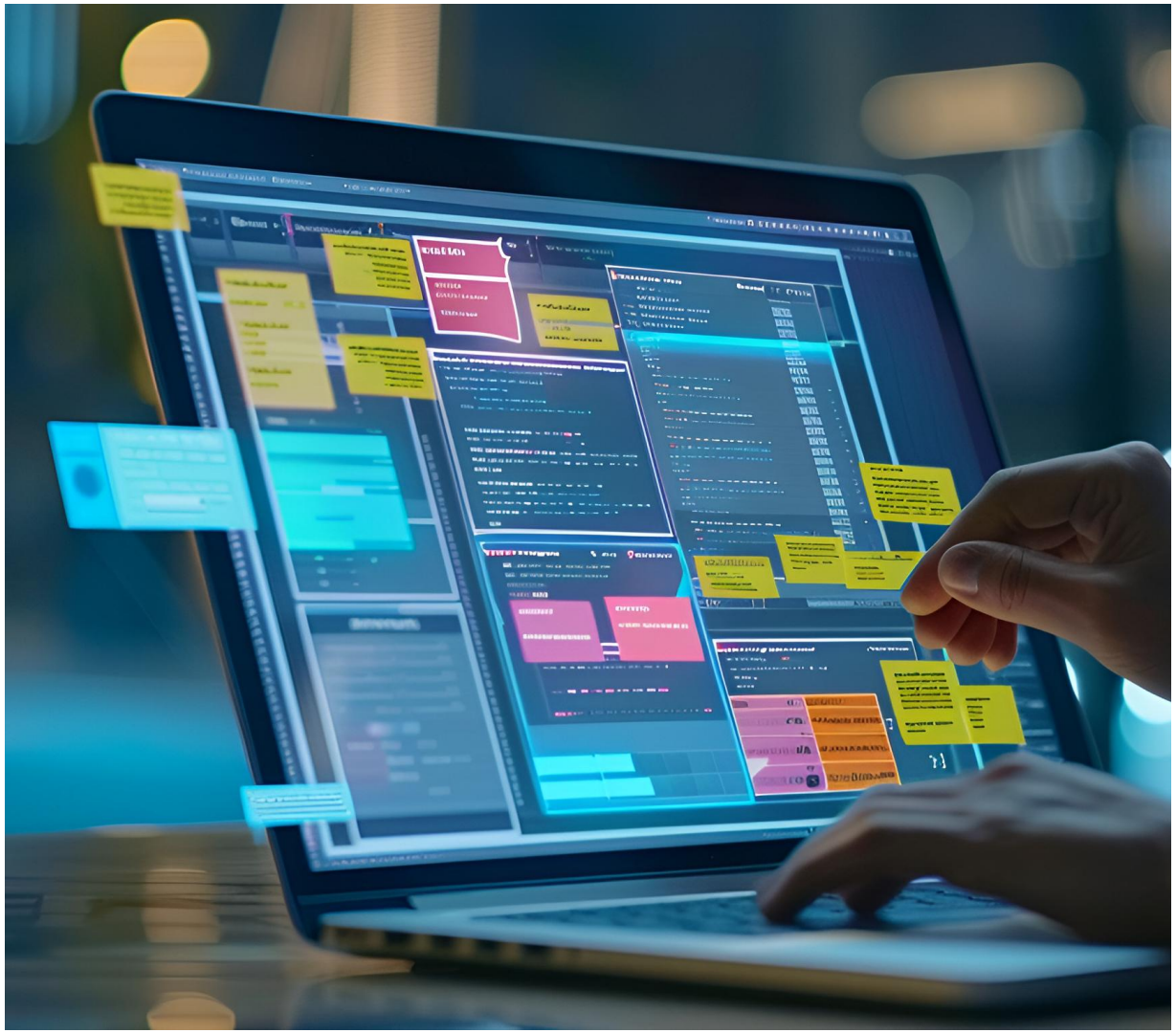
Annotations

Tied to their Object

Many Key-Value-Pairs

Annotatable Objects

- Same as Comments
- Indexes
- (more to come)



Annotations: Key-Value Pairs

Keys and Values

- free Text

Keys

- mandatory
- 1-1024 characters

Values

- optional
- 0-4000 characters
- JSON possible

```
create table job_assignments (
  emp_id     raw(16)  not null
      annotations (SurrogateKey,
                   PK), -- key only annotations
  job_id    raw(16)  not null
      annotations (SurrogateKey, -- Indicates that these columns
                   PK), -- is part of the primary key. Remember,
                        -- annotations are free form.
  start_ts   timestamp with time zone
      annotations (content 'actual start of work',
                   UI_Display
              '[{"format":"long"},
                {"tz: "utc"},
                {"label": "Work Start"}]'),
  changed_by varchar2(100)
      annotations (UI_Display '[{"visibility":"hidden"}]',
                   Classification 'change tracking'),
  changed    timestamp  with time zone
      annotations (UI_Display '[{"visibility":"hidden"}]',
                   Classification 'change tracking')
)
annotations (relation '["emps", "jobs"]',
             content 'Assignments of employees to jobs');
```

Annotations: Syntax

Annotations

- cannot be created standalone

create object

- annotations-clause

alter object

- add
- drop
- replace

modifier

- if [not] exists

```
alter table job_assignments
  modify start_ts
    annotations (
        drop if exists "CONTENT",
        add if not exists missing_annotation,
        replace ui_display
             '[{"format":"short"},
               {"tz: "local"},
               {"label": "Work Start"}]');
```

Annotations: Metadata Views

[USER|ALL|DBA]_

ANNOTATIONS	Annotation Names
ANNOTATIONS_USAGE	Most Details
ANNOTATION_VALUES	Only Values

```
-- Metadata query
select column_name,
       annotation_name,
       annotation_value
from   user_annotations_usage
where object_name = 'JOB_ASSIGNMENTS'
order by column_name nulls first ,annotation_name, annotation_value;

COLUMN_NAME    ANNOTATION_NAME       ANNOTATION_VALUE
_____________  ____________________  ____________________________________________
               CONTENT               Assignments of employees to jobs
               RELATION              ["emps", "jobs"]
CHANGED        CLASSIFICATION        change tracking
CHANGED        UI_DISPLAY            [{"visibility":"hidden"}]
CHANGED_BY     CLASSIFICATION        change tracking
CHANGED_BY     UI_DISPLAY            [{"visibility":"hidden"}]
EMP_ID         PK
EMP_ID         SURROGATEKEY
JOB_ID         PK
JOB_ID         SURROGATEKEY
START_TS       MISSING_ANNOTATION
START_TS       UI_DISPLAY            [{"format":"short"},
                                      {"tz: "local"},
                                      {"label": "Work Start"}]
```

Coming Soon

SQL Developer workflow for AI Enrichment for Metadata

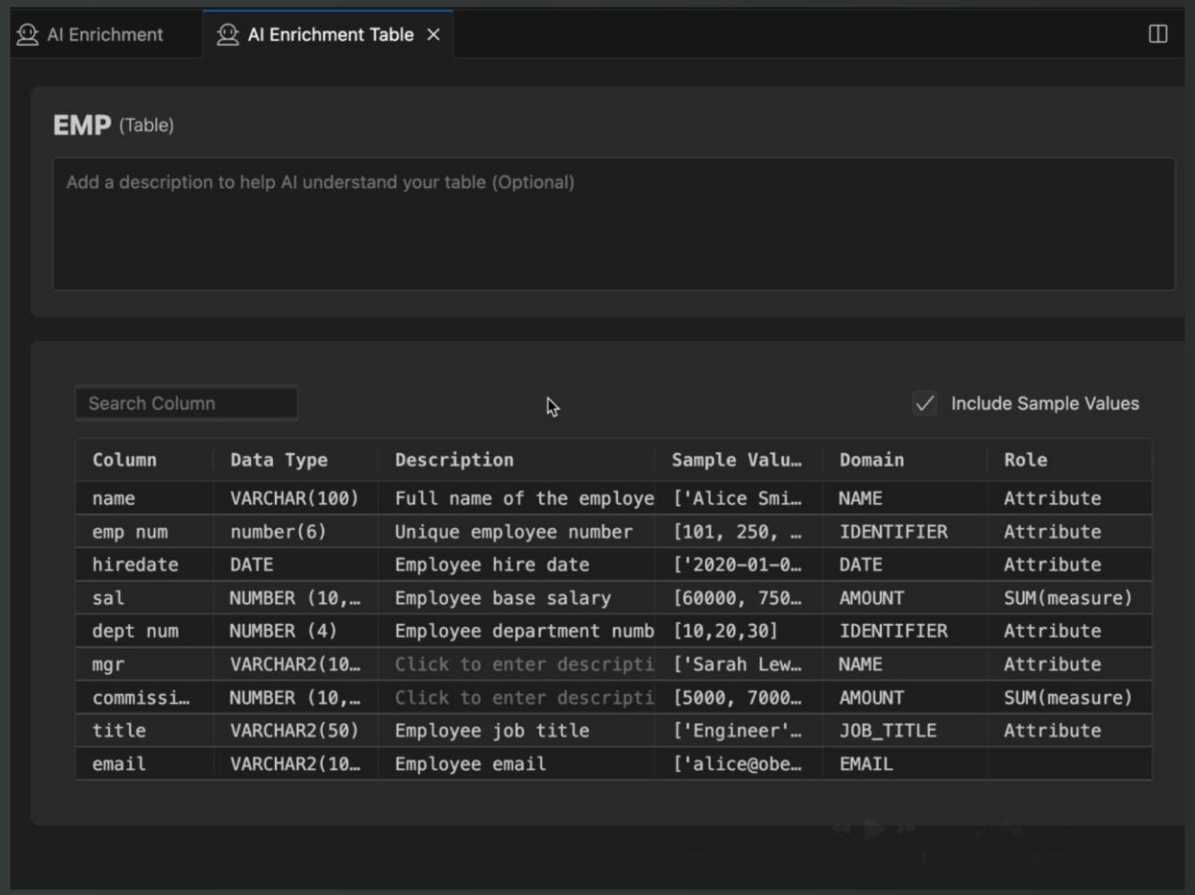
Helping users to add annotations to explain data to AI

Metadata enrichment workflow that allows users to:

- Annotate schemas
- Annotate tables/views within schema
- Annotate columns in each table/view

Optional AI-assisted annotation suggestions

Continuous report on the number of tables enriched



Coming Soon

SQL Developer workflow for AI Enrichment for Metadata

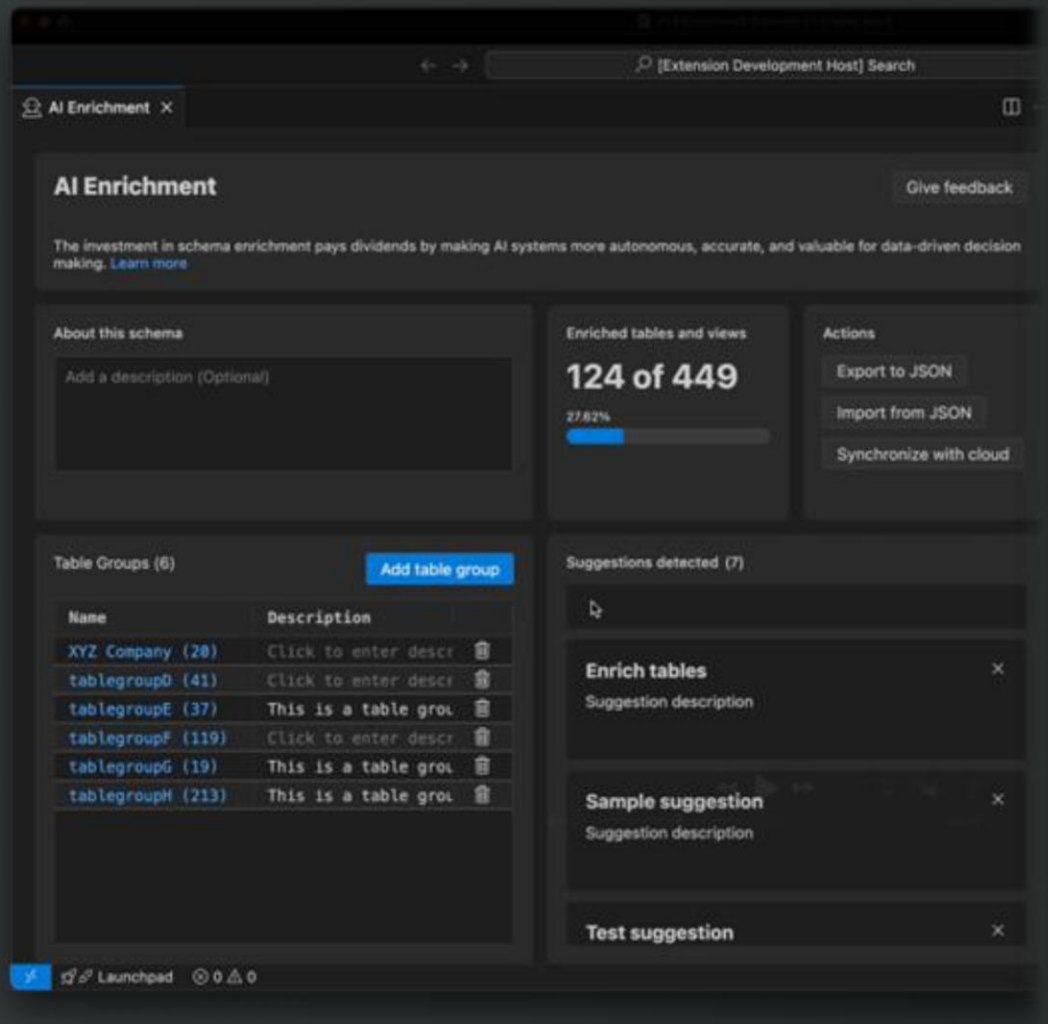
Helping users to add annotations to explain data to AI

Metadata enrichment workflow that allows users to:

- Annotate schemas
- Annotate tables/views within schema
- Annotate columns in each table/view

Optional AI-assisted annotation suggestions

Continuous report on the number of tables enriched

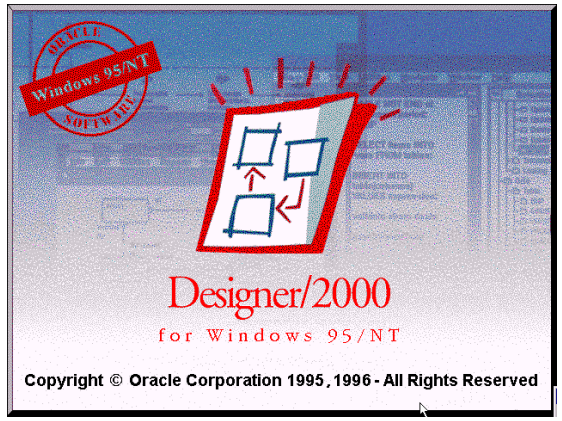


Data Use Case Domains

Data Use Case Domains - History

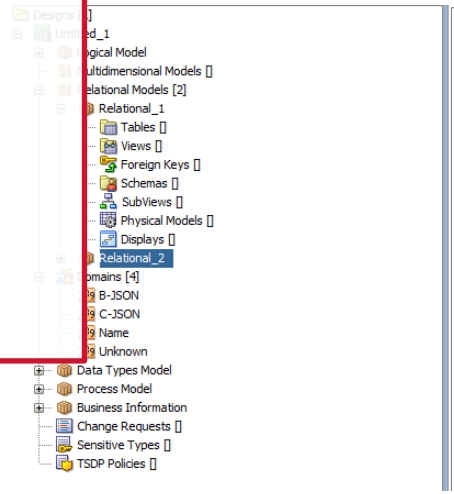
Domains in Design Tools

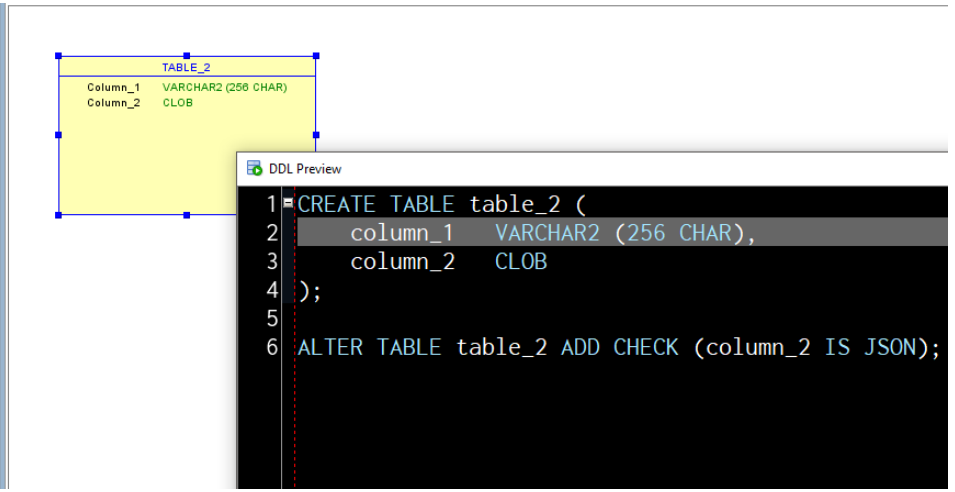
- “since ever”
- define custom data types with addons
- keep data type consistent across all tables
- Change all columns at once



Domains the Database

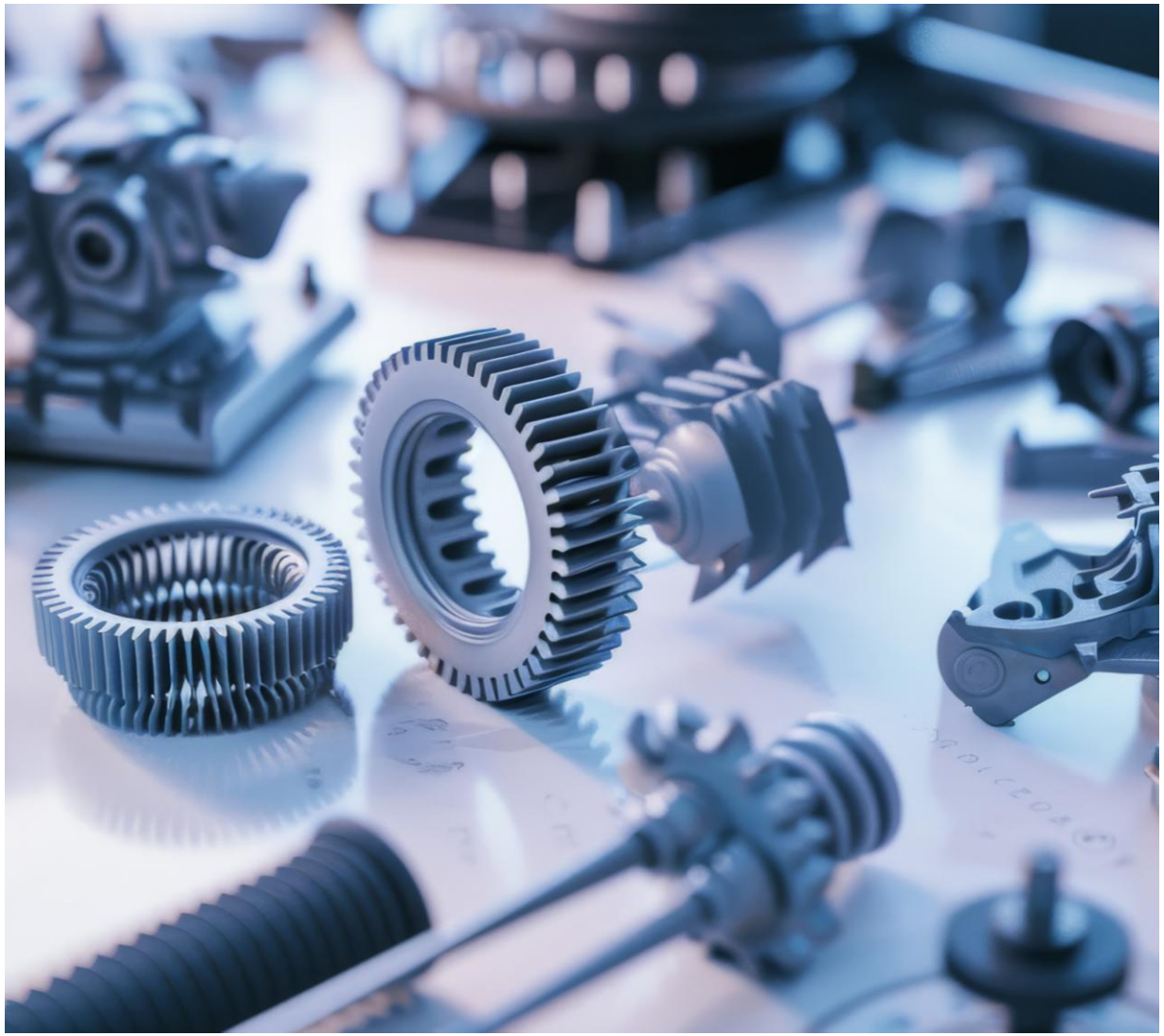
- SQL-Standard:2023
- Oracle 23ai – with enhancements
- PostgreSQL





Data Use Case Domains: Components

- Data Type
- Check Constraints
- Sort Function
- Display Function
- Collation
- Annotations



Data Use Case Domains: Syntax Example

```
create domain uuid
    as varchar2(36)
        not null
        check (regexp_like(uuid,
  '^[0-9a-f]{8}-[0-9a-f]{4}-[0-9a-f]{4}-[0-9a-f]{4}-[0-9a-f]{12}$'
                )
        );

create table jobs(job_id uuid);

desc  jobs

Name      Null?    Typ
_________ ________ ____________________________
JOB_ID    NOT NULL VARCHAR2(36) DOMAIN UUID

insert into jobs(job_id)
  values ('12345678-1234-1234-1234-123456789abc');

-- 1 row inserted.

insert into jobs(job_id)
  values ('1234');

-- ORA-11534: check constraint (ROBBIE.SYS_C008419)
--     involving column JOB_ID
--     due to domain constraint ROBBIE.SYS_DOMAIN_C0045
--     of domain ROBBIE.UUID violated
```

```
create domain uuid
    as varchar2(72);

create table j1(job_id varchar2(72));
create table j2(job_id varchar2(36));

alter table j1 modify (job_id) add domain uuid;
-- Table J1 altered.

alter table j2 modify (job_id) add domain uuid;
-- Table J2 altered.

drop domain if exists uuid force;

create domain uuid
    as varchar2(72) strict;

alter table j2 modify (job_id) add domain uuid;
-- ORA-11517: the column data type does not
--            match the domain column
```

Data Use Case Domains: Validate JSON

```
create table jobs
  (job json validate
    '{ "type": "object",
       "properties": { "job_id": { "type": "string"} }
     }');

create domain json_job as json validate '{
    "type": "object",
    "properties": {
        "job_id": {
            "type": "string",
            regexp: "^[0-9a-f
        }
    },
    "required": ["job_id"]
}';

create table jobs2(job json_j
```

```
select table_name, SEARCH_CONDITION
  from user_constraints
  where table_name Like 'JOBS%'
    and constraint_type ='C';

TABLE_NAME  SEARCH_CONDITION
──────────  ──────────────────────────────────────────────────────────────────────
JOBS        "JOB" IS JSON VALIDATE '{ "type": "object", "properties": {
JOBS2       "JOB" IS JSON  FORMAT JSON (LAX VALIDATE '{"type":"object","properties":{"job_id

select *
  from user_json_domain_schema_columns;

DOMAIN_NAME   COLUMN_NAME   CONSTRAINT_NAME    JSON_SCHEMA
───────────   ───────────   ───────────────    ──────────────────────────────────────────────────
JSON_JOB      JSON_JOB      SYS_DOMAIN_C0052   {"type":"object","properties":{"job_id":{"type":"s
```

Data Use Case Domains: Functions

Part of domain	`domain_display(<column>)`
	`domain_sort(<column>)`
Identify & Test	`domain_name(<column>)`
	`domain_check(<domain_name>, <value>)`
	`domain_check_type(<domain_name>, <value>)`
Cast	`cast (<column> as domain <domain_name>)`

```
create domain short_string as varchar2(30);

create domain uuid
  as raw(16) default sys_guid() not null
  annotations (UI_Display 'UUID', Classification 'uuid')
  display  lower(
           substr(lpad(rawtohex(uuid),32,'0'), 1, 8)||'-'||
           substr(lpad(rawtohex(uuid),32,'0'), 9, 4)||'-'||
           substr(lpad(rawtohex(uuid),32,'0'), 13, 4)||'-'||
           substr(lpad(rawtohex(uuid),32,'0'), 17, 4)||'-'||
           substr(lpad(rawtohex(uuid),32,'0'), 21));

create table j3
  (id uuid primary key,
   name short_string);

insert into j3 (name) values ('23ai Domains');

select id, domain_display(id) from j3;

ID                                DOMAIN_DISPLAY(ID)
_________________________________ ____________________________________
22BC6158C0EA05E4E0630200590A169C 22bc6158-c0ea-05e4-e063-0200590a169c

with uuids as
  (select sys_guid() as id connect by level ≤ 3)
select id,
       domain_display(id),
       domain_check(uuid, id),
       domain_display(cast (id as domain uuid))
  from uuids;

ID                                DOMAIN_DISPLAY(ID) DOMAI DOMAIN_DISPLAY(CAST(IDASDOMAINUUID))
_________________________________ __________________ _____ ____________________________________
24845C04908E04C9E0630200590A862F                     true  24845c04-908e-04c9-e063-0200590a862f
24845C04908F04C9E0630200590A862F                     true  24845c04-908f-04c9-e063-0200590a862f
24845C04909004C9E0630200590A862F                     true  24845c04-9090-04c9-e063-0200590a862f
```

Data Use Case Domains: Data Dictionary Views

[USER|ALL|DBA]_

- DOMAINS
- DOMAIN_COLS
- DOMAIN_CONSTRAINTS
- JSON_DOMAIN_SCHEMA_COLUMNS


Multi Column Domains

Multi Column Data Use Case Domains

Multiple Columns

- can be grouped

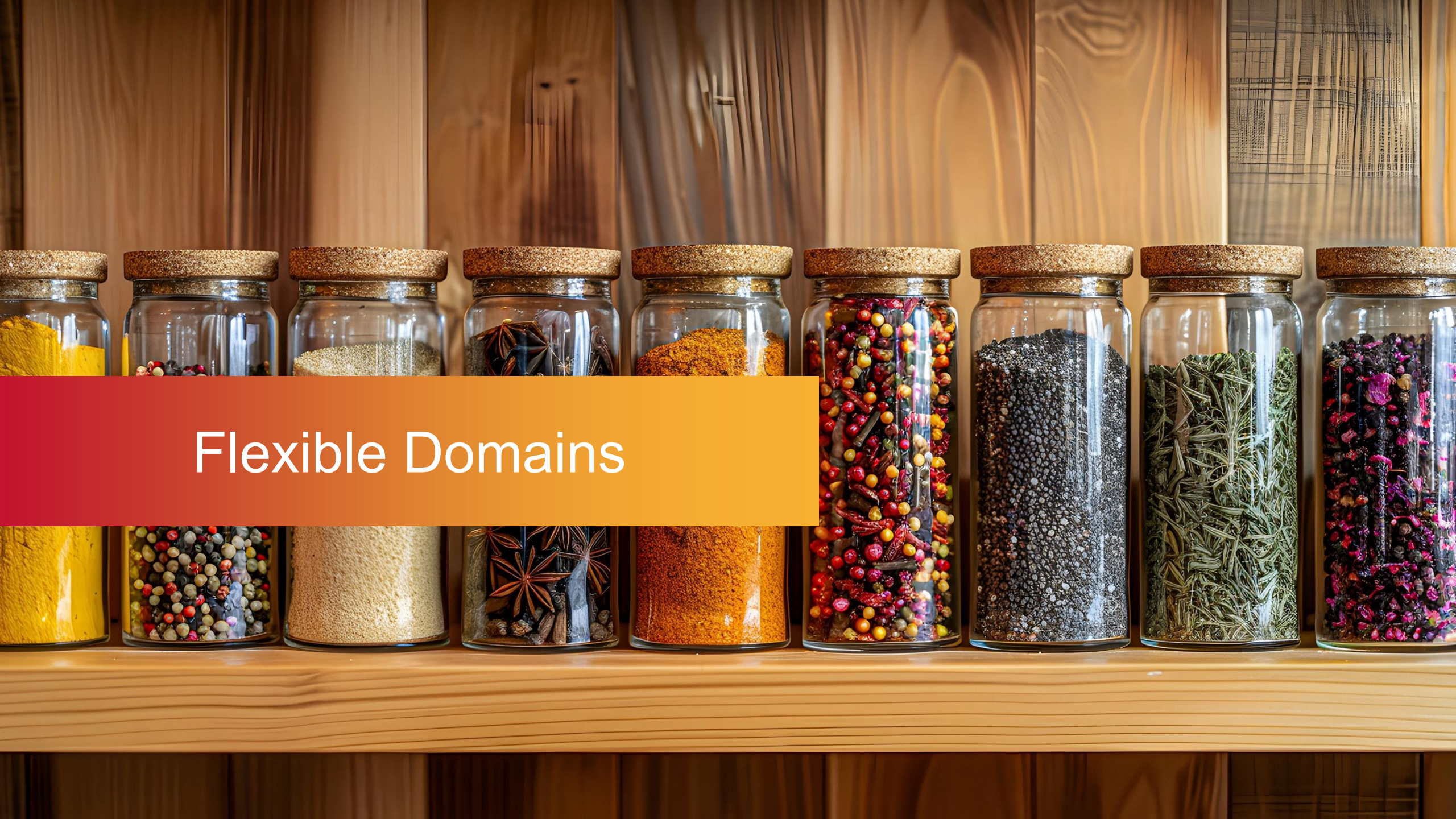
Check constraints

- can reference all domain cols

Table Columns

- with matching data type must be present

```
drop table if exists addresses;
create domain adr_domain as
( street as varchar2(255)
, zip    as varchar2(10)
, city   as varchar2(255)
, country as varchar2(255)
) check (zip is null or regexp_like(zip, '^\d{5}$'));

create table addresses
( id      number primary key,
  street  varchar2(255),
  zip     varchar2(10),
  city  varchar2(255),
  country varchar2(255),
  domain adr_domain (street, zip,city,country));
```


Flexible Domains

Flexible Data Use Case Domains (1/2)

Define

multiple (multi column) Domains

Choose

for every table row
what Domain to use

Endless Possibilities

e.g. Addresses:
• choose check constraints and
• display_function
based on country code

Killer Feature for JSON Validation

• Choose JSON Schema based on content
• Handle different API-Versions
• ….

```
create domain job_type_a
as -- this is a multi-column domain
(job_details as json validate '{
    "type": "object",
    "properties": {"type_a": {"type": "string"}},
    "required": ["type_a"]
}');

create domain job_type_b
as -- add as many column and constraints as needed
(job_details as json validate '{
    "type": "object",
    "properties": {"type_b": {"type": "string"}},
    "required": ["type_b"]
}');

create FLEXIBLE domain job_types
   -- number of columns must match subdomains
   (job_details)
   choose domain using (job_mode varchar2(2 char)) from
   -- options: decode() and case statements
   -- case with full comparison expression only
   case
        when job_mode = 'A' then job_type_a(job_details)
        when job_mode = 'B' then job_type_b(job_details)
        else job_type_a(job_details) -- default
   end;
```

Flexible Data Use Case Domains (2/2)

```
create table jobs_flex
    (id number primary key,
     job_mode varchar2(2 char),
     job_details JSON);

alter table jobs_flex
    modify (job_details, job_mode) add domain job_types;

insert into jobs_flex (id, job_mode, job_details)
    values (1, 'A', '{"type_a": "A job"}'),
           (2, 'B', '{"type_b": "B job"}');
-- 2 rows inserted.
insert into jobs_flex (id, job_mode, job_details)
    values (3, 'A', '{"type_b": "A job"}');

-- ORA-11534: check constraint (ROBBIE.SYS_C008451)
--   involving columns JOB_MODE, JOB_DETAILS
--   due to domain constraint ROBBIE.SYS_DOMAIN_C0059
--   of domain ROBBIE.JOB_TYPES violated
```

Data Use Case Domains – Enum „Exotic Flavor“

Read Only Table

- Key – Value Pairs
- Keys may have aliases
- Keys are Object Names → Uppercase or Quotes
- Check Constraint
  - Ensures only defined Values can be inserted
- Sort- and Display-Function

Default Data Type

- number sequence starting with 1
- Starting point can be adjusted

Custom Data Type

- By assigning values
- First assignment determines data type

Persistance in Code

- Check Constraints
- Domain Functions
- → Not for large Volumes

```
-- generated number sequence starting with 1 as enum values
create domain job_status_domain
    as enum (created,
             scheduled,
             accepted,
             in_progress,
             paused,
             completed);

-- Enum Domains can be used as read-only tables
select *
  from job_status_domain;

ENUM_NAME    ENUM_VALUE
___________  ___________
CREATED                1
SCHEDULED              2
ACCEPTED               3
IN_PROGRESS            4
PAUSED                 5
COMPLETED              6

6 rows selected.
```

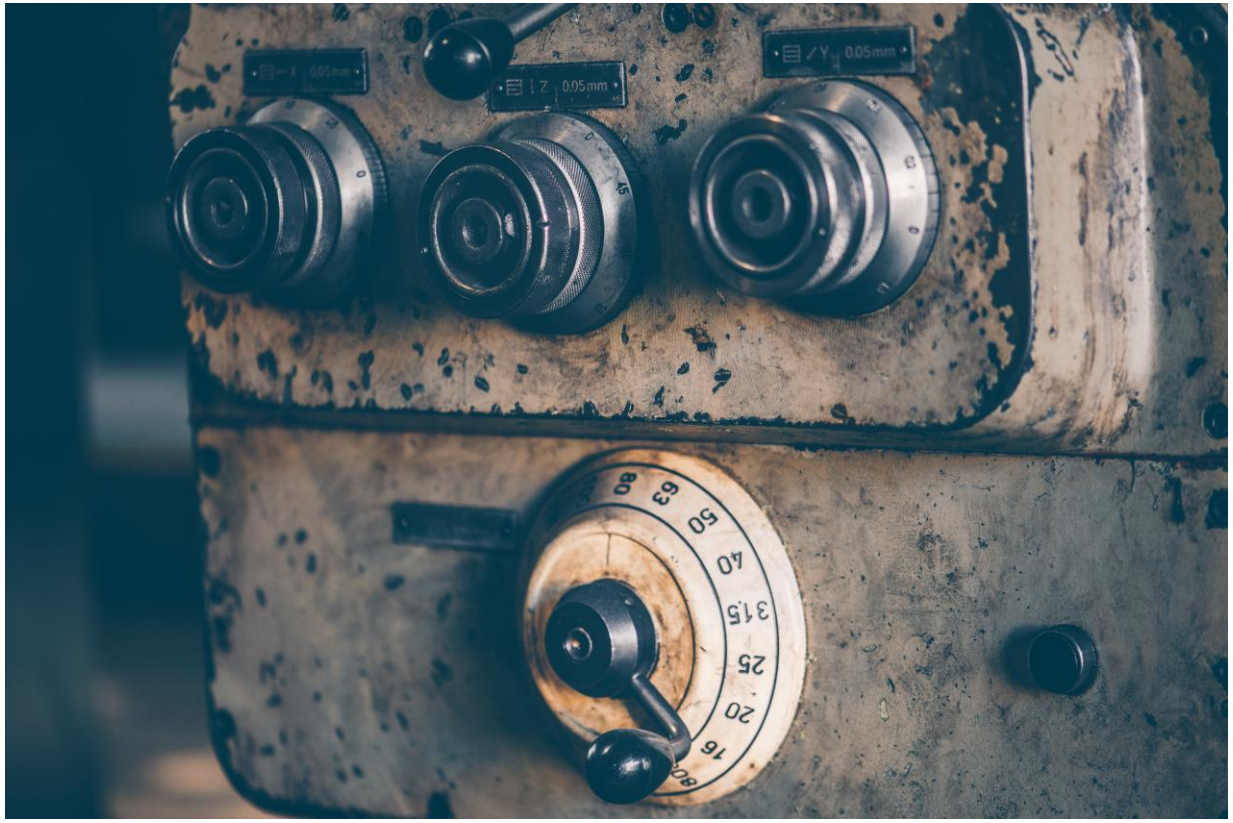
Data Use Case Domains – Enum Basic Usage

```
create table jobs
(
    id number generated always as identity primary key,
    job_name varchar(255),
    status job_status_domain
);

insert into jobs (job_name, status)
values ('Job a', 1),
       ('Job b', 2),
       ('Job c', job_status_domain.accepted),
       ('Job d', job_status_domain.in_progress),
       ('Job e', job_status_domain.paused),
       ('Job f', job_status_domain.completed)
;

6 rows inserted.
```

```
-- Fails because only 6 values are defined in job_status_domain
insert into jobs (job_name, status)
values ('Job g', 7);

ORA-11534: check constraint (ROBBIE.SYS_C0024412)
   involving column STATUS
   due to domain constraint ROBBIE.SYS_DOMAIN_C0052
   of domain ROBBIE.JOB_STATUS_DOMAIN violated

select job_name, status, domain_display(status)
  from jobs;

JOB_NAME    STATUS    DOMAIN_DISPLAY(STATUS)
_________   _______   ______________________

Job a             1   CREATED
Job b             2   SCHEDULED
Job c             3   ACCEPTED
Job d             4   IN_PROGRESS
Job e             5   PAUSED
Job f             6   COMPLETED
```

Data Use Case Domains – Enum Adjust Start Point

```
-- Create basic enumeration domain starting with 0
create domain job_status_domain
    as enum (created = 0,    -- Starting with 0
             scheduled,
             accepted,
             in_progress,
             paused,
             completed);

select *
  from job_status_domain;

ENUM_NAME      ENUM_VALUE
_____________  ___________
CREATED                  0
SCHEDULED                1
ACCEPTED                 2
IN_PROGRESS              3
PAUSED                   4
COMPLETED                5

6 rows selected.
```



Data Use Case Domains – Enum Aliases, Values, Order Function (1)

```
-- Create more complex enumeration domain
-- Use aliases and varchar2 enum values
create domain job_status_domain
    as enum (INS  = created  = 'Created',
             PLN  = planned  = 'Scheduled',
             ACC  = accepted   = 'Accepted',
             PRG  = inprogress   = 'In Progress',
             HLD  = paused   = 'On Hold',
                    -- Note the double quotes
             FIN  = "done"     = 'Completed'
             )
        order case(job_status_domain)
                when 'Created'      then 30
                when 'Scheduled'    then 40
                when 'Accepted'     then 70
                when 'In Progress'  then 20
                when 'On Hold'      then 80
                when 'Completed'    then 10
                else 99
            end;
```

```
-- Beacause of the aliase, we get 12 entries
select *
  from job_status_domain;

ENUM_NAME     ENUM_VALUE
_____________ _____________
INS           Created
CREATED       Created
PLN           Scheduled
PLANNED       Scheduled
ACC           Accepted
ACCEPTED      Accepted
PRG           In Progress
INPROGRESS    In Progress
HLD           On Hold
PAUSED        On Hold
FIN           Completed
done          Completed

12 rows selected.
```

Data Use Case Domains – Enum Aliases, Values, Order Function (2)

```
create table jobs
(
    id number generated always as identity primary key,
    job_name varchar(255),
    status job_status_domain
);

insert into jobs (job_name, status)
values ('Job a', 'Created'),
       ('Job b', job_status_domain.planned),
       ('Job c', job_status_domain.acc),
       ('Job d', job_status_domain.prg),
       ('Job e', job_status_domain.hld),
       ('Job f', job_status_domain."done")
       ;          -- Note the double quotes
```

```
select job_name, status
      , domain_display(status) as disp_f
      , domain_order(status) as order_f
  from jobs
  order by domain_order(status);

JOB_NAME    STATUS          DISP_F    ORDER_F
_________   _____________   _______   _______
Job f       Completed       FIN            10
Job d       In Progress     PRG            20
Job a       Created         INS            30
Job b       Scheduled       PLN            40
Job c       Accepted        ACC            70
Job e       On Hold         HLD            80

6 rows selected.
```

Data Use Case Domains – Check Constraint

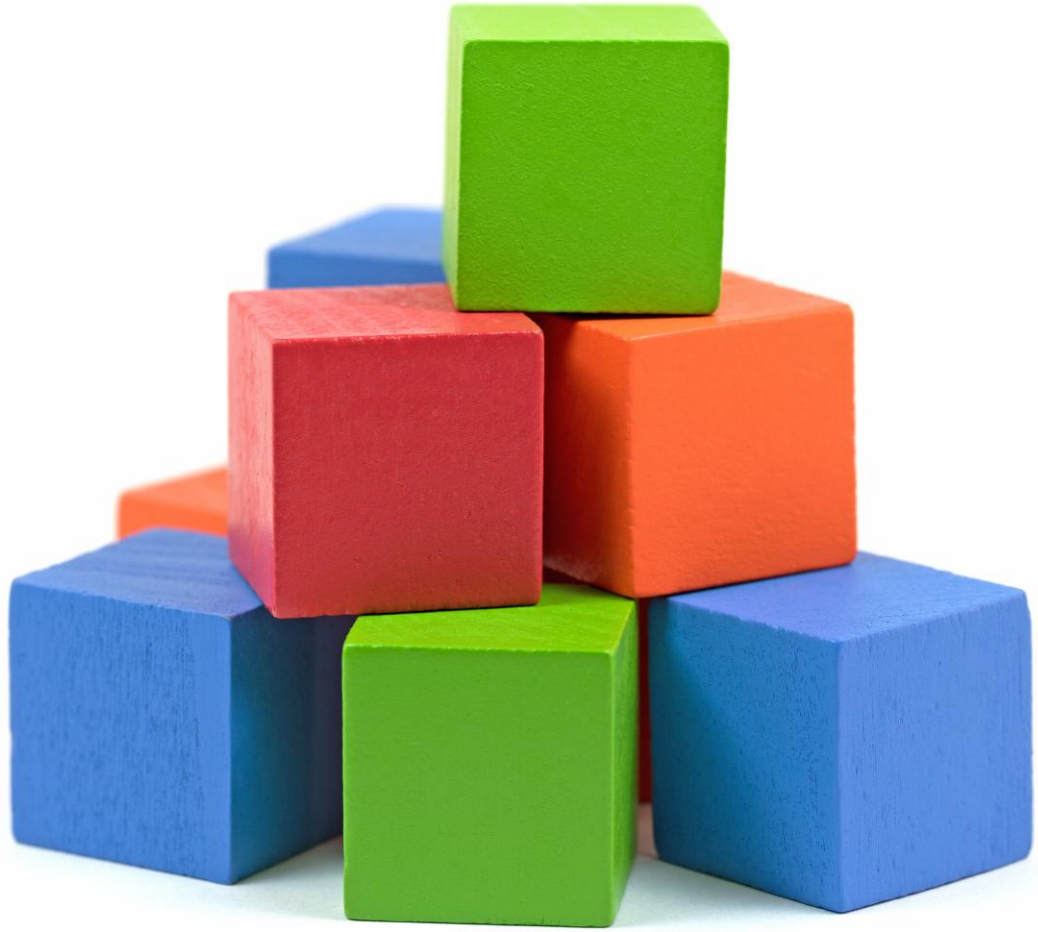
```
desc jobs

Name        Null?       Type
----------  ----------  ----------------------------------
ID          NOT NULL    NUMBER
JOB_NAME                VARCHAR2(255)
STATUS                  VARCHAR2(22) DOMAIN JOB_STATUS_DOMAIN

select table_name, constraint_type, constraint_name, SEARCH_CONDITION
  from user_constraints
 where table_name = 'JOBS';

TABLE_NAME  CONSTRAINT_TYPE  SEARCH_CONDITION
----------  ---------------  ------------------------------------------------------------------------------
JOBS        C                  "ID" IS NOT NULL
JOBS        C                  ("STATUS"='Created' OR "STATUS"='Scheduled' OR "STATUS"='Accepted'
                               OR "STATUS"='In Progress' OR "STATUS"='On Hold' OR "STATUS"='Completed')
JOBS        P
```

Pre-defined Domains

Pre Defined Data Use Case Domains

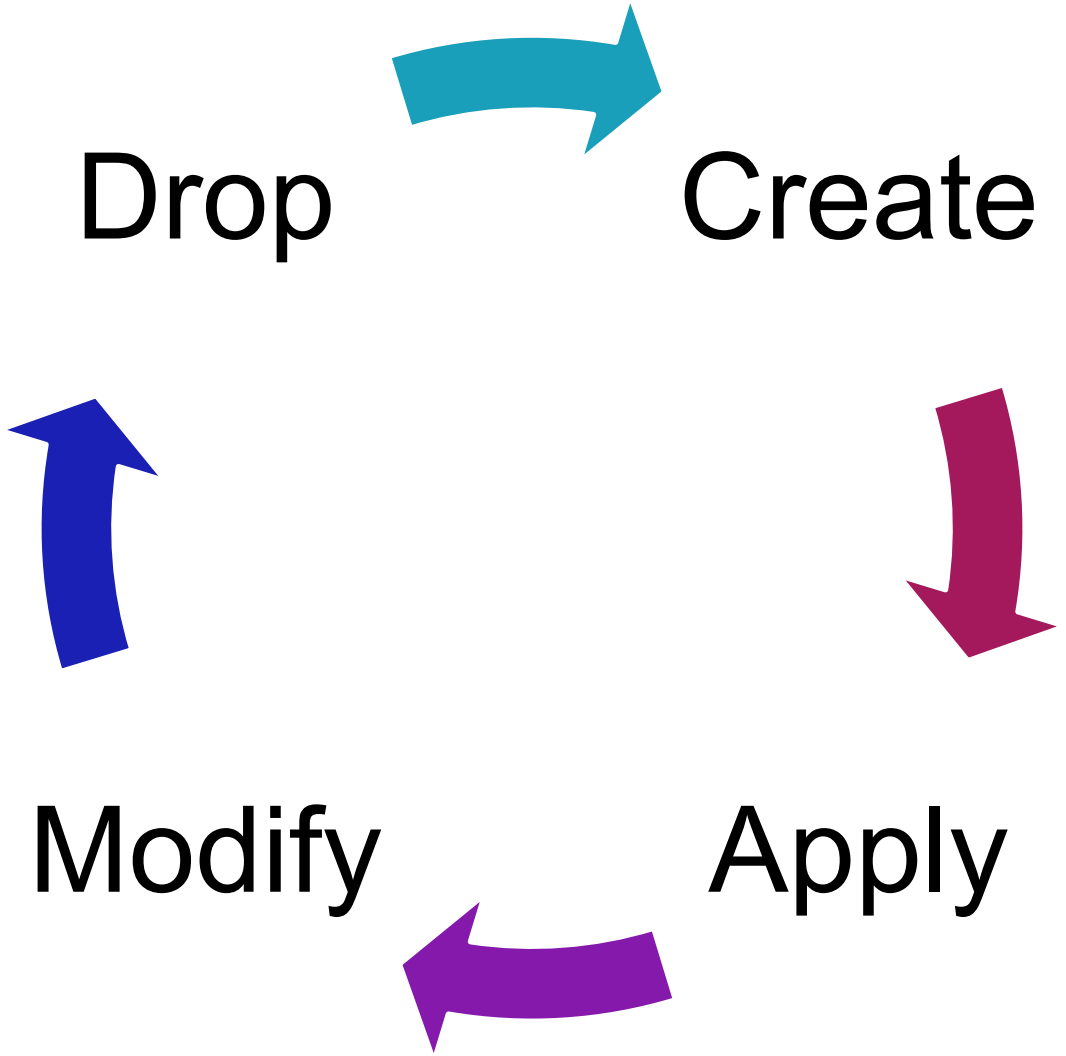
There are 109 (23.6) predefined Domains

Technical	UUID4
	IPv4 Address
	IPv6 Address
	Subnet Mask
	CIDR
Mathematical	Measure
	Percent
	Ratio
	Numbers (Negative, Postive, Non-Zero
Communications	Email
	Social Media IDs
US National	Adresses
	Phone Numbers
	Social Security Number
	US Licences Plate




Domain Lifecycle

Data Use Case Domain Lifecycle



Data Use Case Domain: Modfiy

Modify (alter domain) options are limited to

Display Function	add
	modfiy
	drop
Order Function	add
	modify
	drop
Annotations	add
	modify
	drop

Data Use Case Domain: Drop & Re-Create

DROP DOMAIN <name>

Fails if associated with columns

drop domain <name> FORCE

disassociates domain from columns
removes
- domain check constraints
- domain defaults
- domain annotations

drop domain <name> force PRESERVE

removes domain
keeps constraints & defaults on columns
→ Attention: possible double constraints

Data Usecase Domains: Demo

Data Intention Language - Annotations

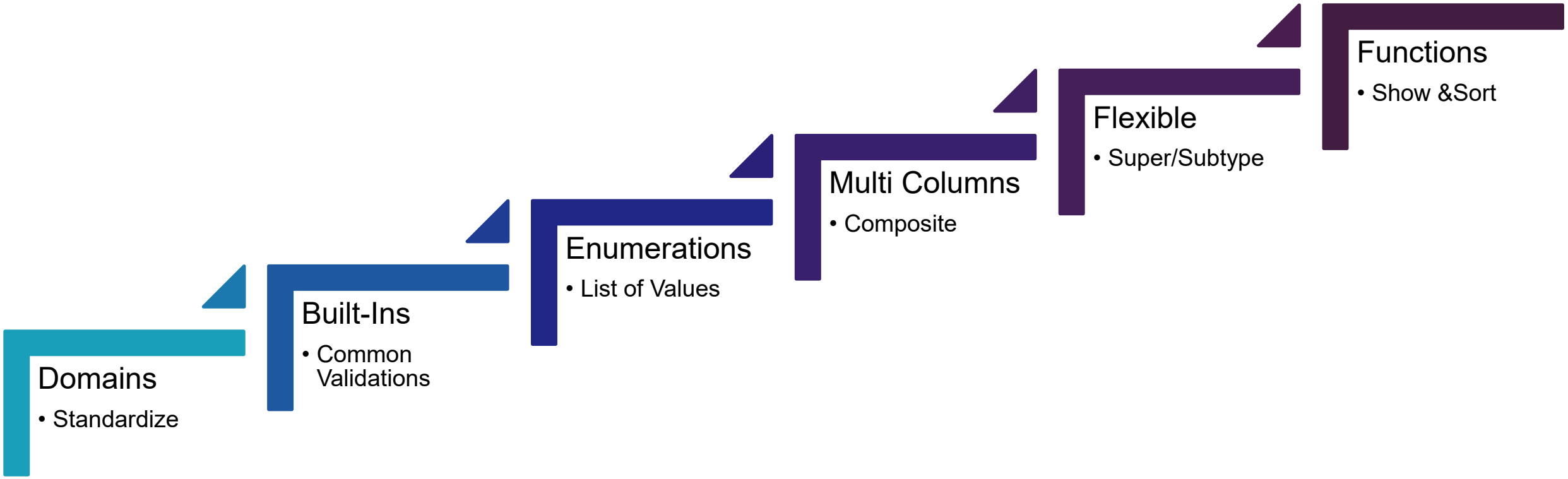
Context

- Key-Value Pairs
- Application Metadata

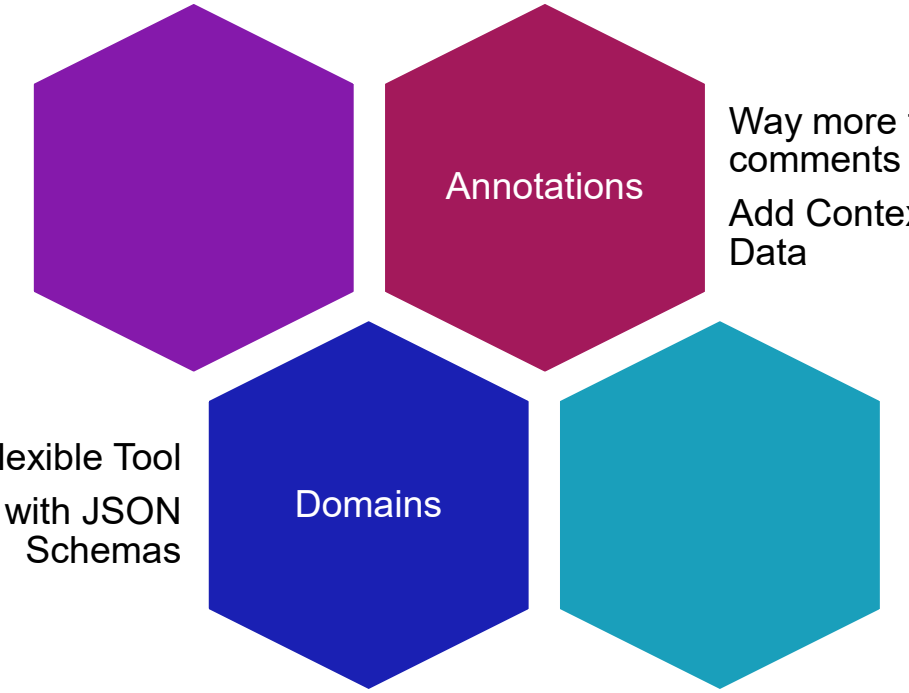
Understanding your Data

- Devs
- Users
- AI

Data Intention Language - Data Use Case Domains



Data Intention Language: Annotations and Domains



Way more than better comments

Add Context to your Data

Flexible Tool

Powerfull with JSON Schemas

ora2know

The German Oracle Database Community