COLLATIONS IN POSTGRESQL:

THE GOOD, THE BAD AND THE UGLY.

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OVERVIEW

- What are collations?
- *the good*: practical use for developers
- *the bad*: things to watch out for
- *the ugly*: avoid data corruption
- Takeaways
- History / Future

WHAT ARE COLLATIONS?

- *i18n* (internationalisation) feature
- part of *locale*
- related to *encoding*

LOCALE

Set of parameters to tell an application how users would expect it's output (and behaviour).
On `*NIX` traditionally set by environment variables:

- `LANG`: default main setting (preferred)
- `LC_ALL`: for temp. override
- `LC_MESSAGES`: Language of user interface, `LANGUAGE` for a preference list
- `LC_TIME`: format of date and time
- `LC_NUMERIC`: decimal delimiter, grouping
- `LC_MONETARY`: Currency format and symbols
- `LC_CTYPE`: Character classification, case folding
- `LC_COLLATE`: String collation rules
- …

Applied: `(LANGUAGE) > LC_ALL > LC_* > LANG`

COLLATIONS

- order of characters / symbols
- like learnt in elementary school
- simple but depending on culture

HOW ARE COLLATIONS RELEVANT?

- `ORDER BY`: order of output
- `WHERE`: searching data
- `JOIN`: matching data
- `UNIQUE`: define a sense of equality
- `PARTITON BY`: distributing data

Often supported by Indexes.

PROVIDERS

Functionality provided by the OS Different implementations

- POSIX: `libc` (Linux: `glibc`, `μClibc`, `musl`; *BSD `libc`; Windows: `msvcrt`; macOS: `libSystem`)
  must match encoding
- ICU: common, portable library
  supported for most encodings, mainly UTF8

ICU: pg10

`libc`	ICU
`strcoll`	`ucol_strcoll`
`strxfrm`	`ucol_getSortKey`
…	…

`strcoll`

decide if one string is *smaller*, *equal* or *greater* then a second one

- `<0`: string1 less than string2
- `0`: string1 identical to string2
- `>0`: string1 greater than string2

UNICODE NORMAL FORMS

Unicode: ~~Glyphs~~ Graphemes, Codepoints, Encodings

- composition
  - NFC/NFKC: composed form: `Ä` (U+00C4)
  - NFD/NFKD: decomposed form `A+◌̈` (U+0041 U+0308)
- equivalent (NFC / NFD) vs. compatible (NFKC / NFKD)
  - equal glyphs, meaning
  - variants, formatting, functions

UTR #15: UNICODE NORMALIZATION FORMS Full chart

THE GOOD

powerful support in PostgreSQL

NORMAL FORMS IN POSTGRESQL

- check
  `text IS [NOT] [form] NORMALIZED → boolean`
- convert
  `normalize( text [, form ] ) → text`

  `form` is key word: NFC (default), NFD, NFKC, or NFKD

pg13, faster in pg14

NON-DETERMINISTIC COLLATION

Depending on the use case differences may be irrelevant:

- Case: a = A
- Normal form a+◌̈= ä
- Accent: ä = a
- Phonebook: ä = ae

By default if `strcoll = 0`, `strcmp` is used as a tie-breaker, unless the collation is defined `non-deterministic`.

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`COLLATE` CLAUSE

- per **Expression**
  ```
  ORDER BY city COLLATE "de_CH"
  WHERE a < b COLLATE "C"
  ```
- per **Column** or **Index**
  ```
  CREATE TABLE t (c TEXT COLLATE "en_US")
  CREATE INDEX ON t (c COLLATE "cs_CZ")
  ```
- per **Domain** (and Composite and Range Types)

Default collateable types: `TEXT`, `VARCHAR`, `CHAR`

pg9.1

ORDER OF PRECEDENCE

1. explicit in expression
2. from column / domain
3. database default

Must be unambiguous, but 2. can mix collations in case the operator does not require a collation (`||` vs. `>`)

Useful for testing:
`COLLATION FOR (<expression>)` can return NULL if undefined / mixed

pg9.2

DEFAULT COLLATIONS

Collation not configurable in Session or Config, no GUCs like `datestyle`

- compile time: `--with-icu`
- cluster creation: inherited from environment or set explicitly
  `initdb --encoding= --locale= --lc-collate= --lc-ctype=`
- database creation: inherited from template
  `CREATE DATABASE name [ENCODING [=] encoding] [LC_COLLATE [=] lc_collate] [LC_CTYPE [=] lc_ctype];`

global: pg6.1, DB level: pg8.4, ICU: pg10

where is ICU on cluster/db level?

ICU AS DEFAULT COLLATION

- cluster creation:
  `initdb --locale-provider=icu --icu-locale=` *`icu_locale`*
- database creation:
  `CREATE DATABASE name LOCALE_PROVIDER [=] icu [ ICU_LOCALE [=] icu_locale ] TEMPLATE [=] template0`

`icu_locale` is ICU locale ID, not PostgreSQL `collation` object name

POSIX locale needs to be set *as well*

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no non-deterministic default collations

CREATE COLLATIONS: SYSTEM

Provided by external libraries with their rule definition sets:

LIBC

- `$ locale -a`
  show all available locales
- `$ locale`
  show current settings
- `$ locale -ck LC_ALL`
  show it's definition
- `/etc/locale.gen` add/uncomment entry, then compile with `$ locale-gen` or package manager / vendor specific script `$ localectl`
- You can view the sources. Watch out for symlinks in generated locales

ICU

- APIs
  `ucol_countAvailable()`
  `ucol_getAvailable()`
  `ucol_getDisplayName()`
- CLDR: Common Locale Data Repository
  cldr.unicode.org, interactive browser, GitHub, as Chart
- LDML: Locale Data Markup Language (UTS #35)

CREATE COLLATIONS: DB

- first, the locale need to be present in the OS
- during `initdb` all available collations are registered in `template0` catalog `pg_collation`, can be re-run later per DB: `pg_import_system_collations()`
  - **libc** `locale -a`, adds a less platform specific alias
  - **ICU** `uloc_getAvailable()` and `uloc_getDisplayName`, appends `-x-icu` to name
- `CREATE COLLATION` command

```
CREATE COLLATION [ IF NOT EXISTS ] name (
    [ LOCALE = locale, ]
    [ LC_COLLATE = lc_collate, ]
    [ LC_CTYPE = lc_ctype, ]
    [ PROVIDER = provider, ]
    [ DETERMINISTIC = boolean, ]
    [ VERSION = version ]
)
CREATE COLLATION [ IF NOT EXISTS ] name FROM existing_collation
```

- `PROVIDER`: `libc` / `icu`
- `LOCALE`: shortcut for `LC_COLLATE` and `LC_CTYPE`

```
SELECT * FROM pg_collation;
\dOS+
```

```
[local] bussmann@~=# \dOS+ de*
                                           List of collations
|   Schema   |     Name      |   Collate     |    Ctype      | Provider | Deterministic? |       Description
|------------|---------------|---------------|---------------|----------|----------------|------------------------
| pg_catalog | de-AT-x-icu   | de-AT         | de-AT         | icu      | yes            | German (Austria)
| pg_catalog | de-BE-x-icu   | de-BE         | de-BE         | icu      | yes            | German (Belgium)
| pg_catalog | de-CH-x-icu   | de-CH         | de-CH         | icu      | yes            | German (Switzerland)
| pg_catalog | de-DE-x-icu   | de-DE         | de-DE         | icu      | yes            | German (Germany)
| pg_catalog | de-IT-x-icu   | de-IT         | de-IT         | icu      | yes            | German (Italy)
| pg_catalog | de-LI-x-icu   | de-LI         | de-LI         | icu      | yes            | German (Liechtenstein)
| pg_catalog | de-LU-x-icu   | de-LU         | de-LU         | icu      | yes            | German (Luxembourg)
| pg_catalog | de-x-icu      | de            | de            | icu      | yes            | German
| pg_catalog | de_AT         | de_AT         | de_AT         | libc     | yes            |
| pg_catalog | de_AT.UTF-8   | de_AT.UTF-8   | de_AT.UTF-8   | libc     | yes            |
| pg_catalog | de_CH         | de_CH         | de_CH         | libc     | yes            |
| pg_catalog | de_CH.UTF-8   | de_CH.UTF-8   | de_CH.UTF-8   | libc     | yes            |
| pg_catalog | de_DE         | de_DE         | de_DE         | libc     | yes            |
| pg_catalog | de_DE.UTF-8   | de_DE.UTF-8   | de_DE.UTF-8   | libc     | yes            |
| pg_catalog | default       |               |               | default  | yes            | database's default coll
(15 rows)
```

LOCALE NAME SYNTAX

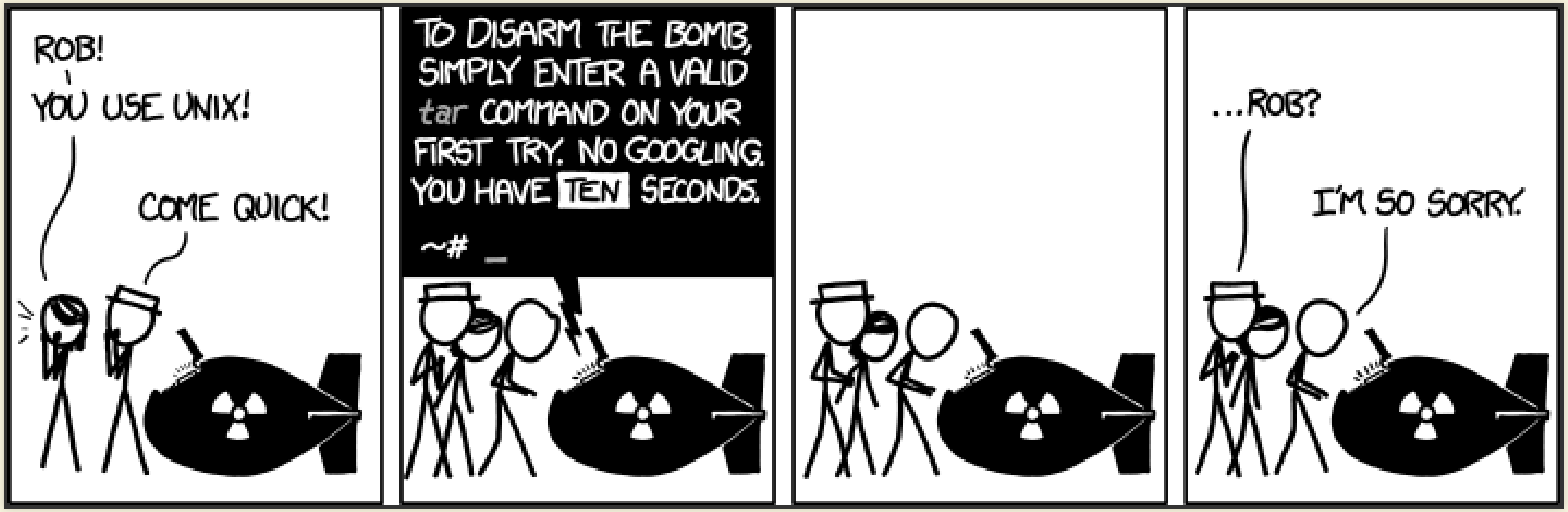
- **POSIX**: `language[_TERRITORY][.codeset][@modifier]`
  - `de_DE.ISO-8859-15@euro`
  - `ca_ES.UTF-8@valencia`
  - `de_CH.utf8`
- **BCP47**: `language[-Script][-REGION][-u- unicodeextension ][-x-privateuse]`
  - `de-u-co-phonebk-kn-true-ks-level2`
  - `sr-Cyrl-XK` (Serbian, Cyrillic, Kosovo)
  - `en`
  - `und-x-icu`
- **Legacy ICU**: `[language[_Script][_REGION]][@key=value[;key=value]...]`
  - `de_DE@collation=phonebook,colNumeric=yes,colStrength=secondary`
  - `@collation=emoji` (using 'root' collation)
  - `de@collation=phonebook`

BCP47 UNICODE EXTENSION

- Tailoring of collation behaviour from CLDR
- Syntax is defined in RFC6067:
  `[-u-key-type[-type]...][-key-type[-type]...]]...]` keys unique
- keys and types defined in LDML / UTS#35, as XML (with alias names), interactive demo

key	type	description
`co`	`standard`, `phonebk`, `search`, `trad`, `emoji`, `phonetic`	Collation type. e.g. Traditional Spanish ordering, Phonebook ordering
`ks`	`level1`, `level2`, `level3`, `level4`, `identic`	Max collation strength: *Primary*: base letters, *Secondary*: accents, *Tertiary*: mainly case, *Quaternary*: used in some collations, *identical*: unicode codepoints (like `ucs_basic`)
`kb`	`true`, `false`	Sort second level (accents) backward: e.g. Canadian French
`kc`	`true`, `false`	Insert and use a strict case level between second and third level. Useful when ignoring accents (level1)
`kf`	`upper`, `lower`, `false`	Force to sort upper or lower case first
`kk`	`true`, `false`	Normalise to NFD before sorting
`kn`	`true`, `false`	Use natural sort for numbers. Useful for filenames, addresses.
`kr`	`digit`, `space`, `grek`, `latn`, …	Order of scripts. Multiple types

…


ROB!
YOU USE UNIX!
COME QUICK!
TO DISARM THE BOMB, SIMPLY ENTER A VALID tar COMMAND ON YOUR FIRST TRY. NO GOOGLING. YOU HAVE TEN SECONDS.
~# _
...ROB?
I'M SO SORRY.

SPECIAL COLLATIONS

not ICU dependent:

- `"default"`: database default collation
- `"C"` `=` `"POSIX"`: by encoded byte value
- `"ucs_basic"`: by Unicode code point (in UTF8)

ICU:

- `"und-x-icu"`: ‘root’ collation (DUCET) with a reasonable language-agnostic sort order UTS #10: UNICODE COLLATION ALGORITHM, as chart
- `'und-u-co-eor'` European Ordering Rules
- `'und-u-co-emoji'`: ‘root’ collation with Emoji ordering (note: does conflict with languages), UTS #51: UNICODE EMOJI, categories

USEFUL COLLATION DEFINITIONS

```sql
CREATE COLLATION "de-phonebook" (provider = icu, locale = 'de-u-co-phonebk');
CREATE COLLATION "de-natural" (provider = icu, locale = 'de-u-kn-true');
CREATE COLLATION "de-listing" (provider = icu, locale = 'de-u-co-phonebk-kn-true-ks-level2', deterministic =
CREATE COLLATION "und-emoji" (provider = icu, locale = 'und-u-co-emoji');
CREATE COLLATION "und-normalize" (provider = icu, locale = 'und-u-kk-true', deterministic = false);
CREATE COLLATION "und-nocase" (provider = icu, locale = 'und-u-ks-level2', deterministic = false);
CREATE COLLATION "und-noaccent" (provider = icu, locale = 'und-u-ks-level1-kc-true', deterministic = false);
CREATE COLLATION "und-noaccent-nocase" (provider = icu, locale = 'und-u-ks-level1', deterministic = false);
CREATE COLLATION "und-ignorepunctuation" (provider = icu, locale = 'und-u-ks-level3-ka-shifted', determinist
```

```
# SELECT * FROM string_to_tab
'-b,a,...d,  c', ',') x
ORDER BY x
COLLATE "und-ignorepunctuatio
```

```
   x
 a
 -b
   c
 ...d
```

```
 de-DE-x-icu  | de-phonebook
--------------+---------------
 ad           | ad
 äd           | ae
 ae           | äd
 af           | af
```

```
# SELECT * FROM string_to_table(
'file-1,file-10,file-2,file-9', ','
ORDER BY x COLLATE "de-natural";
```

```
    x
 file-1
 file-2
 file-9
 file-10
```

Uses of CType:

```
# SELECT upper('i' COLLATE "tr-x-ic
initcap('Bußmann' COLLATE "C");
```

```
 upper | initcap
 İ     | BußMann
```

```
# SELECT regexp_split_to_table(
'Glædelig jul' collate "C", '[^\w]'
```

```
 regexp_split_to_table
 Gl
 delig
 jul
```

WORKAROUNDS THAT MAY BE REPLACED

- `citext` extension
- `unaccent` extension
- Order / Compare / Index on function: `lower(x)` / `my_recursive_natural_sort(x)`
- ~~`ILIKE`~~
- Sort within application
- Many bugs due to unexpected, undetermined sort order
- More bugs due to different understanding what ‘unique’ means

THE BAD

Things to watch out for

PERFORMANCE

- Locale-aware comparisons are slower vs. locale `C`: `strcoll` is more expensive, needs NUL-terminated strings (requires `strcpy`) and possibly `strcmp` as tie-breaker.
- *Non deterministic collations* (ICU only) are slower then deterministic ones, as they need to use the locale-aware comparison even if only equality needs to be tested.
  - But they should perform better than the functional / extension workarounds.
- Several optimisations may not be usable:
  - *Abbreviated keys*, a powerful `btree` optimisation introduced with 9.5 had to be disabled in 9.5.2 due to bugs in `glibc`'s implementations of `strxfrm` in several locales. The API promise `strcoll(a,b) == strcmp( strxfrm(a), strxfrm(b) )` didn't hold. It is still available in `C` (using `strcmp` only anyhow) or if compiled with `TRUST_STRXFRM`.
    - With ICU collations it is available again, often even faster and with a wider platform support.
- Using ICU may require encoding conversion.

AVAILABILITY

- Locales need to be present in the OS
- OS need not to lie about their collation support
  - there is no POSIX collation support for Unicode encoding in `*BSD`, incl. Darwin/macOS. (Illumos, Dragonfly and FreeBSD did some joint work in 2015)
- With ICU: No check if collation definition is valid and in CLDR. `CREATE COLLATION "superpower" (provider=icu, locale='invalid-like-hell');` does not throw an error. Instead, ~~fuzzy~~ well-defined fallback till root collation.
  - Tip: Extension `icu_ext` provides `icu_collation_attributes()` to check how a Collation ID is interpreted by the library.
- `libc` collations need to match Encoding
- Non-Deterministic collations cannot be used as default collation

icu_ext

```
# SELECT * FROM icu_collation_attributes('de-u-co-phonebk-kn-true-ks-level2');
┌─────────────┬────────────────────────────────────────────────────────────────────────────────────┐
│  attribute  │                                       value                                        │
├─────────────┼────────────────────────────────────────────────────────────────────────────────────┤
│ displayname │ German (Sort Order=Phonebook Sort Order, colnumeric=yes, colstrength=secondary)    │
│ kn          │ true                                                                               │
│ kb          │ false                                                                              │
│ kk          │ false                                                                              │
│ ka          │ noignore                                                                           │
│ ks          │ level2                                                                             │
│ kf          │ false                                                                              │
│ kc          │ false                                                                              │
│ kv          │ punct                                                                              │
│ version     │ 153.120.42                                                                         │
└─────────────┴────────────────────────────────────────────────────────────────────────────────────┘
```

```
# SELECT icu_transform('Слон',
  'Cyrl-Latn');
┌───────────────┐
│ icu_transform │
├───────────────┤
│ Slon          │
└───────────────┘
```

```
# SELECT loc, icu_number_spellout(1234, loc)
FROM (values ('en'),('fr'),('de'),('ru'),('ja')) AS s(loc);
┌─────┬───────────────────────────────────────────┐
│ loc │            icu_number_spellout            │
├─────┼───────────────────────────────────────────┤
│ en  │ one thousand two hundred thirty-four      │
│ fr  │ mille deux cent trente-quatre             │
│ de  │ eintausendzweihundertvierunddreißig       │
│ ru  │ одна тысяча двести тридцать четыре        │
│ ja  │ 千二百三十四                              │
└─────┴───────────────────────────────────────────┘
```

PATTERN MATCHING - PERFORMANCE

- locale aware index not useable for prefix-pattern matching, as collations are context-sensitive:
  - in Czech alphabet: `...b, c ,d, ... h, ch ,i ...` so `abc < abcz < abch`

```
# SELECT 'c' < 'd' COLLATE "cs-x-icu", 'ch' < 'd' COLLATE "cs-x-icu";
┌──────────┬──────────┐
│ ?column? │ ?column? │
├──────────┼──────────┤
│ t        │ f        │
└──────────┴──────────┘
```

  - an index using e.g. `cs_CZ.UTF-8` is sorted accordingly and cannot be used to fulfil a condition like `WHERE col LIKE 'abc%'`.
- As a workaround either create an index with explicit `COLLATE "C"` or using the `text_pattern_ops` opclass. In that case collation-unaware comparison operators are used: `~>~`, `~>=~`, `~<=~`, `~<~`
  - opclasses `gin_trgm_ops` / `gist_trgm_ops` for index-supported trigram pattern matching from the `pg_trgm` extension are not locale aware, too.

```
# \d cz_test
          Table "toolbox.cz_test"
+--------+------+-----------+----------+---------+
| Column | Type | Collation | Nullable | Default |
+--------+------+-----------+----------+---------+
| t      | text | cs_CZ     |          |         |
+--------+------+-----------+----------+---------+
Indexes:
    "cz_test_t_idx" btree (t)
    "cz_test_t_idx1" btree (t COLLATE "C")
    "cz_test_t_idx2" btree (t text_pattern_ops)

# EXPLAIN (COSTS OFF) SELECT * FROM cz_test WHERE t LIKE 'abc%';
+----------------------------------------------------------------+
|                          QUERY PLAN                            |
+----------------------------------------------------------------+
| Index Only Scan using cz_test_t_idx2 on cz_test                |
|   Index Cond: ((t ~>=~ 'abc'::text) AND (t ~<~ 'abd'::text))   |
|   Filter: (t ~~ 'abc%'::text)                                  |
+----------------------------------------------------------------+

# DROP INDEX cz_test_t_idx2;
# EXPLAIN (COSTS OFF) SELECT * FROM cz_test WHERE t LIKE 'abc%';
+------------------------------------------------------------+
|                        QUERY PLAN                          |
+------------------------------------------------------------+
| Index Only Scan using cz_test_t_idx1 on cz_test            |
|   Index Cond: ((t >= 'abc'::text) AND (t < 'abd'::text))   |
|   Filter: (t ~~ 'abc%'::text)                              |
+------------------------------------------------------------+

# DROP INDEX cz_test_t_idx1;
# EXPLAIN (COSTS OFF) SELECT * FROM cz_test WHERE t LIKE 'abc%';
+--------------------------------+
|          QUERY PLAN            |
+--------------------------------+
| Seq Scan on cz_test            |
|   Filter: (t ~~ 'abc%'::text)  |
+--------------------------------+
```

PATTERN MATCHING - FEATURE

- pattern matching not possible for *non-deterministic* collations

```
# SELECT 'Bußmann' LIKE '%MANN' COLLATE "und-nocase";
ERROR:  nondeterministic collations are not supported for LIKE
```

Why? case folding is not bijective:

```
# SELECT upper('ß' COLLATE "de-DE-x-icu"), lower('SS' COLLATE "de-DE-x-icu");
┌───────┬───────┐
│ upper │ lower │
├───────┼───────┤
│ SS    │ ss    │
└───────┴───────┘
(1 row)
```

- Same for `~` and `SIMILAR TO` (regex pattern matching)
- As a workaround for case-insensitive matching: assign `COLLATE "C"` and use `ILIKE` or `~*`
  - create an supporting index with opclass `gin_trgm_ops` / `gist_trgm_ops` to speed-up

THE UGLY

avoid data corruption

COLLATION ORDER IS NOT ALWAYS STABLE.

- *OS*: Collation rules change. Collation providers get bug fixes.
- *DB*: Order is persisted in indexes at time of insert.
- If collation changes, bad effects can happen - without even noticing.
  - **Index corruption**: Some queries may not find certain records anymore, Joins behave strangely.
    `SET enable_indexscan = OFF;` and data reappears
  - **Constraint violation**: Duplicated values in `UNIQUE` / PK column. `CHECK` -Constraints not valid.
  - **Partition routing**: rows are inserted or searched in the wrong partition
  - Unlikely PostgreSQL will throw an error about that.

LIBC UPDATES

- Depending on the policy of the OS distribution. Likely during major updates, bugfixes may be included earlier
- **`glibc 2.28`** (released 2018-08-01) ~~was~~ is a particularly dangerous update.
  - Updates locale data according to *ISO/IEC 14651:2016*, which was synchronised with Unicode 9
  - Last big update in 2000/2001, since then only minor changes in single collations on a case-by-case basis
  - Changes lots of popular collations (even `en_US`) in an obvious way. Simple test in shell:
    `( echo "1-1"; echo "11" ) | LC_COLLATE=en_US.UTF-8 sort`
  - Known to be rolled out in Debian 10, Ubuntu 18.10, RHEL & CentOS 8, Fedora 29, …
  - Further updates to be expected *ISO/IEC 14651:2019*

- **At risk**: OS is updated with new `libc` / `libicu` and:
  - PostgreSQL `data` directory kept (no or minor PostgreSQL update)
  - `data` directory updated using `pg_upgrade` (major PostgreSQL update)
- **At risk**:
  - Using physical / streaming replication over servers with different versions
  - Restoring physical backups made in a different environment (e.g. `pg_basebackup`)
- **Safe** if:
  - Running in `C` locale only
  - Restoring from logical backup (`pg_dump`)
  - Using logical replication across versions

VERSIONING TO THE HELP

- *most* collation providers support versioning of collation data
- Version is recorded in `pg_collation.collversion` when collation is created
- Current version can be checked using `pg_collation_actual_version()`
- This check is done when the collation is *used* for the first time after start, in case of mismatch a waring is emitted:
  ```
  WARNING:  collation "name" has version mismatch
  ```
- After manually dealing with the issue, issue
  ```
  ALTER COLLATION name REFRESH VERSION;
  ALTER DATABASE name REFRESH COLLATION VERSION;
  ```

pg10+

MITIGATIONS AFTER COLLATION CHANGE

- `REINDEX` all indexes on `text`, `varchar`, `char`, and `citext` that are not using one of the collations `C`, `POSIX`, `ucs_basic` (deterministic)
    - not easily possible to decide if necessary, `amcheck` extension can help
- Unique violation: manual intervention necessary
- Review partitioning keys for `PARTITION BY RANGE`. If affected, reroute tuples manually or run `pg_dump` with option `--load-via-partition-root`
- Do logical replication to new database / cluster

TAKEAWAYS

- Decide what locale to use, ensure the environment provides it, pass it to `initdb`
- “Don’t care” is not an option, explicitly using `C` is - but beware of the CType behaviour then
- Watch carefully for environment changes and the warning message
- Recommendation: make use of ICU, pin version of ICU library package
- At least apply collation selectively when retuning ordered data for display

HISTORY / FUTURE

HISTORY OF LOCALE SUPPORT

- *6.1* (1997): initial cluster wide locale support *(Oleg Bartnunov, …)*
- *8.1* (2005): initial ICU support, replacing the POSIX one (patch for FreeBSD port) *(Palle Girgensohn)*
- *8.3* (2008): FreeBSD patch updated to UTF8 to eliminate conversion to UTF16 *(Petr Jelinek, Palle Girgensohn)*
- *8.4* (2009): database-level `LC_COLLATION` and `LC_CTYPE` *(Heikki Linnakangas, Radek Strnad)*
- *9.1* (2011): collation support for columns, domains, and expressions, `COLLATE` clause, B-tree index support. *(Peter Eisentraut)*
- *9.6* (2016): FreeBSD patch updated with column and expression support *(Palle Girgensohn)*
- *10* (2017): Collation provider infrastructure, ICU collation support (different implementation then in the previous patch) *(Peter Eisentraut)*
- *12* (2019): non deterministic collations for ICU *(Peter Eisentraut)*
- *13* (2020): glibc & Windows Collation Version Support *(Thomas Munro)*, Unicode normalizing functions *(Peter Eisentraut)*
- *14* (2021): BSD Collation Version support *(Thomas Munro)*
- *15* (2022): ICU Default Collations for cluster/DB *(Peter Eisentraut)*

FUTURE IDEAS

- Advocate towards using ICU by default
- Louder error on collation version mismatch
- Support of non-deterministic default collations (incompatible operators used internally)
- Reduce the need to have POSIX locales in addition to ICU
- Let `pg_upgrade` detect collation mismatches and warn or emit reindex script
- Find a way to easy identify affected Indexes
- Access to custom collation tailoring (individual rules)
- Move version tracking from the collation object to individual database objects that use it. Complex patch has been reverted from pg14 *Julien Rouhaud*, *Thomas Munro*
- Allow to load multiple version of the ICU library at runtime

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Swiss PGDay 2023: tba.
www.pgday.ch

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