

Internationalizing the Internet's Domain Name System (DNS)

Root Zone Label Generation Rules

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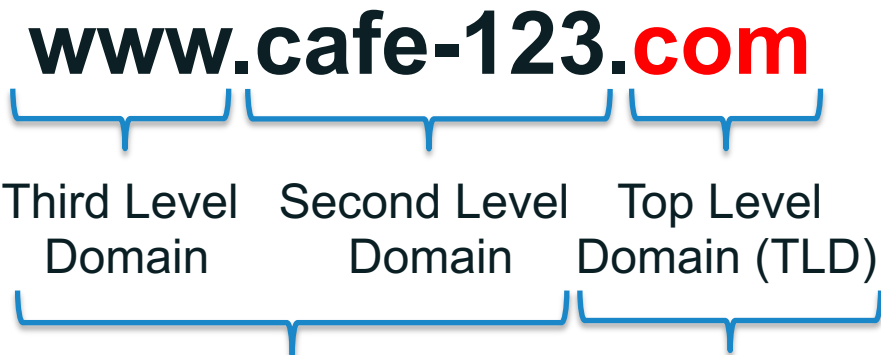
7 November 2023



Overview

- ⦿ Many global Internet users use their own local scripts and may not even be familiar with English letters used in ASCII encoding.
- ⦿ Internationalized Domain Names (IDNs) allow for such users to navigate the Internet in their local languages and scripts, making the Internet more inclusive.
- ⦿ Enabling IDNs requires clear rules for forming valid domain labels.
- ⦿ Root Zone Label Generation Rules (RZ-LGR) define such rules for top-level domains (TLDs).
- ⦿ This presentation provides details on the following aspects of RZ-LGR:
 - Need
 - Design principles
 - Development process
 - Solutions for Repertoire, Variants, and Rules

ASCII Domain Name Label



Forming ASCII Labels

Use LDH

- Letters [A..Z a..z]
- Digits [0..9]
- Hyphen [-]

Label length = 63

Other constraints (e.g., on hyphen)

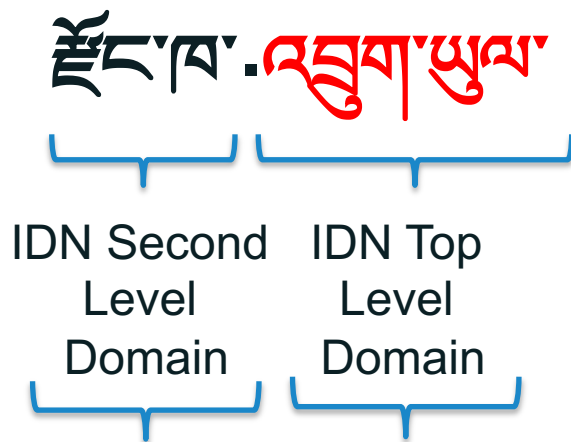
Forming ASCII Labels

Use only Letters

- Letters [A..Z a..z]

Label length = 63

Internationalized Domain Names



Syntax of IDN Labels

Valid U-Label: Unicode code points as constrained by **the “LDH” scheme** within IDNA 2008 – sets baseline limiting to letters, marks and digits

Syntax of IDN Labels

Valid U-Label, further constrained by **the “letter” principle** for TLDs

Internationalized Domain Names in Applications (IDNA)

- ⦿ Internationalized Domain Names for Applications (IDNA) 2008 is developed by the Internet Engineering Task Force (IETF), and consists of multiple protocol documents:
- ⦿ Standard Track:
 - RFC 5890 IDNA: Definitions and Document Framework
 - RFC 5891 IDNA: Protocol
 - RFC 5892 The Unicode Code Points and IDNA
 - RFC 5893 Right-to-Left Scripts for IDNA
- ⦿ Informational Track:
 - RFC 5894 Background, Explanation, and Rationale
 - RFC 5895 Mapping Characters for IDNs in Applications (IDNA) 2008
- ⦿ IDNs must be IDNA 2008 compliant.

Basis for the Root Zone Label Generation Rules (RZ-LGR)

- ⊙ *Internationalized Domain Names for Applications (IDNA): Definitions and Document Framework* ([RFC5890](#)) presents guidance on determining the IDNs.

- ⊙ [Section 2.3.2.3](#) states:
 - DNS zone administrators may impose restrictions, beyond those imposed by DNS or IDNA, on the characters or strings that may be registered as labels in their zones [including the root zone].
 - Because of the diversity of characters that can be used in a U-label and the confusion they might cause
 - such restrictions [“variant definitions and rules beyond those imposed by DNS or IDNA”] **are mandatory** [emphasis added] for IDN registries and zones.
 - even though the particular restrictions are not part of these specifications (the issue is discussed in more detail in [Section 4.3](#) of the Protocol document [[RFC5891](#)]).

Basis for the RZ-LGR

- ⦿ [Section 4.4](#) of RFC 5890 states:
 - It is worth noting that there are no comprehensive technical solutions to the problems of confusable characters.
 - One can reduce the extent of the problems in various ways, but probably never eliminate it.
 - Some specific suggestions about identification and handling of confusable characters appear in a Unicode Consortium publication [[Unicode-UTR36](#)].
 - For example: [combining mark order spoofing](#), [inadequate rendering support](#), and others.

RZ-LGR – The Solution for the Root Zone

- ⦿ To achieve the secure and stable definition of IDNs as top-level domains (TLDs) to support different languages and scripts used globally, Root Zone Label Generation Rules ([RZ-LGR](#)) are needed.
 - Builds on the Internationalized Domain Names for Applications (IDNA) standards including RFCs 5890, 5891, 5892, 5893 and their successors.
 - Uses the principles outlined in RFC 6912.
 - Follows the [LGR Procedure](#) developed by the community.
 - Uses the machine-readable XML based LGR formalism proposed in RFC 7940. Also published is the corresponding human-readable HTML form.
 - Description.
 - Repertoire of code points.
 - Variant code points with types (allocatable, blocked).
 - Label evaluation rules.

Principles Guiding the RZ-LGR Design

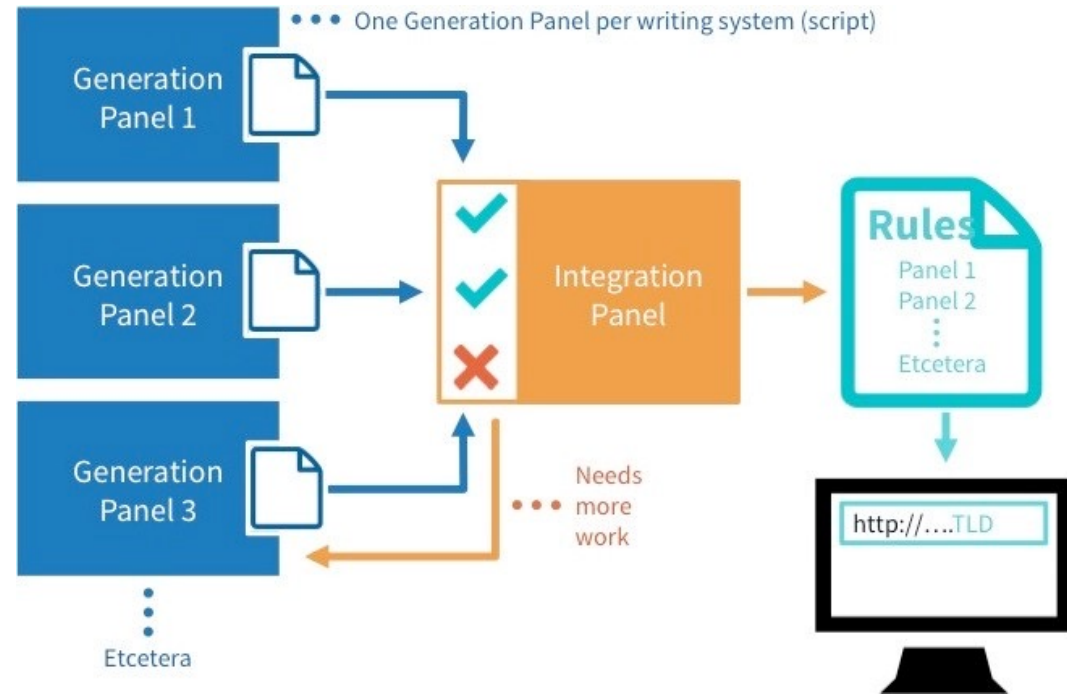
- ⦿ *Principles for Unicode Code Point Inclusion in Labels in the DNS* ([RFC6912](#)) mentions:
 - Most operators of zones should probably not permit registration of U-labels using the entire range.
 - Presents a set of principles that can be used to guide the decision whether a Unicode code point may be included in the repertoire of permissible code points in a U-label in a zone.

Principles Guiding the RZ-LGR Design - [RFC6912](#)

- ⊙ More restrictive rules going up the DNS tree.
- ⊙ Principles Applicable to All Public Zones:
 - **Longevity** - properties of code point stable across Unicode versions.
 - **Least Astonishment** – support expected code points otherwise don't.
 - **Contextual Safety** – prevent where it can be used maliciously.
 - **Conservatism** – when in doubt, don't include.
 - **Inclusion** – excluded unless explicitly included.
 - **Simplicity** – rules to include be simple to understand.
 - **Predictability** – rules to include predictable with requisite knowledge.
 - **Stability** – list of permitted code points to change slowly.
- ⊙ Principle Specific to the Root Zone:
 - **Letter** – allowed code points should be alphabetic (e.g., not digits).

LGR Procedure to Develop the RZ-LGR

- ⦿ Maximal Starting Repertoire as the starting point – by Integration Panel (IP).
- ⦿ Three step process for RZ-LGR:
 - Develop script-based proposal – by community-based Generation Panel (GP) using MSR.
 - Review proposal – jointly by IP and GP.
 - Approval and integration into RZ-LGR – by IP.



Scripts Covered in RZ-LGR

- ⦿ MSR contains 28 scripts aligned with scripts “Recommended” for identifiers by the Unicode standard out of the 161 encoded in Unicode 15.1.
 - Does not include the following categories of script by Unicode standard. Complete script lists in [UAX#31](#) (Tables 4, 5 and 7).
 - “Limited Use” scripts.
 - “Excluded” scripts.
- ⦿ RZ-LGR-5 covers 26 scripts:
 - Arabic, Armenian, Bangla, Chinese (Han), Cyrillic, Devanagari, Ethiopic, Georgian, Greek, Gujarati, Gurmukhi, Hebrew, Japanese (Hiragana, Katakana, and Kanji [Han]), Kannada, Khmer, Korean (Hangul and Hanja [Han]), Lao, Latin, Malayalam, Myanmar, Oriya, Sinhala, Tamil, Telugu, and Thai.
- ⦿ The scripts covered may expand over time.

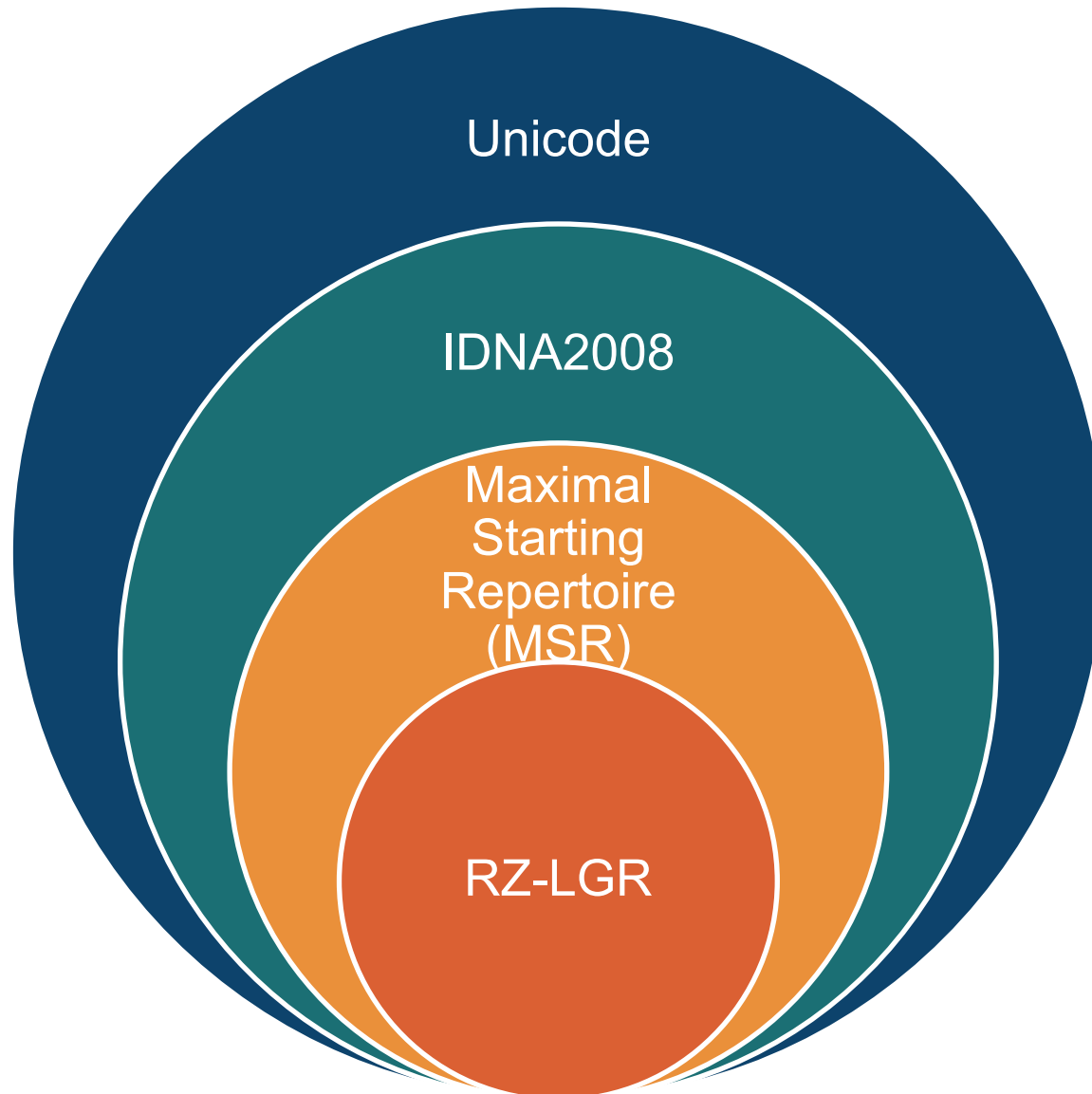
Language Status (using EGIDS) for Inclusion in RZ-LGR

- Many languages can be written using a script.
- Languages analyzed for RZ-LGR selected with a conservative criteria based on their status using Expanded Graded Intergenerational Disruption Scale ([EGIDS](#)):
 - 0-4 – included.
 - 5 – included on case-to-case basis.
 - > 6 – not included as their orthography may not be stable or well understood.
- The languages covered may expand over time.

Level	Label	Description
0	International	The language is widely used between nations in trade, knowledge exchange, and international policy.
1	National	The language is used in education, work, mass media, and government at the national level.
2	Provincial	The language is used in education, work, mass media, and government within major administrative subdivisions of a nation.
3	Wider Communication	The language is used in work and mass media without official status to transcend language differences across a region.
4	Educational	The language is in vigorous use, with standardization and literature being sustained through a widespread system of institutionally supported education.
5	Developing	The language is in vigorous use, with literature in a standardized form being used by some though this is not yet widespread or sustainable.
6a	Vigorous	The language is used for face-to-face communication by all generations and the situation is sustainable.
6b	Threatened	The language is used for face-to-face communication within all generations, but it is losing users.
7	Shifting	The child-bearing generation can use the language among themselves, but it is not being transmitted to children.
8a	Moribund	The only remaining active users of the language are members of the grandparent generation and older.
8b	Nearly Extinct	The only remaining users of the language are members of the grandparent generation or older who have little opportunity to use the language.
9	Dormant	The language serves as a reminder of heritage identity for an ethnic community, but no one has more than symbolic proficiency.
10	Extinct	The language is no longer used and no one retains a sense of ethnic identity associated with the language.



Repertoire Analysis for RZ-LGR



Repertoire Not Shortlisted by MSR

- ⦿ Historic and phonetic extensions to modern scripts.
- ⦿ Code points that pose special risks, e.g., due to instability of encoding.
- ⦿ Code points with strong justification to exclude:
 - Archaic, historic, symbolic, and have little chance to gain use in modern context.
 - PVALID as unintended consequence of the IDNA2008 algorithm.
 - Highly confusable with an existing and common punctuation character.
 - Exclusively used for phonetic, liturgical or other specialized purposes.
- ⦿ Non-spacing combining marks, where precomposed forms are also encoded.
- ⦿ Digits.

Repertoire Shortlisted by Script Community

- ⦿ Include only general purpose and common use code points.
- ⦿ Code points may not be included for many reasons:
 - Historic use or no longer common use:
 - Arabic: ڏ 0690 – historic use only, now replaced by ڏھ.
 - Kannada: ಁ 0CB1 - obsolete character, not in modern use.
 - Gurmukhi: ੁ 0A03 - limited or declining use.
 - Special purpose:
 - Devanagari: U+0929 ण - not in any spoken language; transcribes Dravidian alveolar n.
 - Usage not known in any language included for RZ-LGR:
 - Cyrillic: ё 04ED – possibly used in Sami with EGIDS 8b.
 - Arabic: ڀس 069B – no evidence found of active use.

Arabic Solution Proposed by the Community

	060	061	062	063	064	065	066	067	068	069	06A	06B	06C	06D	06E	06F		075	076	077		08A	08B	08C	08D	08E	08F							
0	ا	ب	ت	ث	ج	ح	خ	د	ذ	ر	ز	س	ش	ص	ض	ط	ظ	ي	ب	ث	ج	ح	خ	د	ذ	ر	ز	س	ش	ص	ض	ط	ظ	ي
1	ا	ب	ت	ث	ج	ح	خ	د	ذ	ر	ز	س	ش	ص	ض	ط	ظ	ي	ب	ث	ج	ح	خ	د	ذ	ر	ز	س	ش	ص	ض	ط	ظ	ي
2	ا	ب	ت	ث	ج	ح	خ	د	ذ	ر	ز	س	ش	ص	ض	ط	ظ	ي	ب	ث	ج	ح	خ	د	ذ	ر	ز	س	ش	ص	ض	ط	ظ	ي
3	ا	ب	ت	ث	ج	ح	خ	د	ذ	ر	ز	س	ش	ص	ض	ط	ظ	ي	ب	ث	ج	ح	خ	د	ذ	ر	ز	س	ش	ص	ض	ط	ظ	ي
4	ا	ب	ت	ث	ج	ح	خ	د	ذ	ر	ز	س	ش	ص	ض	ط	ظ	ي	ب	ث	ج	ح	خ	د	ذ	ر	ز	س	ش	ص	ض	ط	ظ	ي
5	ا	ب	ت	ث	ج	ح	خ	د	ذ	ر	ز	س	ش	ص	ض	ط	ظ	ي	ب	ث	ج	ح	خ	د	ذ	ر	ز	س	ش	ص	ض	ط	ظ	ي
6	ا	ب	ت	ث	ج	ح	خ	د	ذ	ر	ز	س	ش	ص	ض	ط	ظ	ي	ب	ث	ج	ح	خ	د	ذ	ر	ز	س	ش	ص	ض	ط	ظ	ي
7	ا	ب	ت	ث	ج	ح	خ	د	ذ	ر	ز	س	ش	ص	ض	ط	ظ	ي	ب	ث	ج	ح	خ	د	ذ	ر	ز	س	ش	ص	ض	ط	ظ	ي
8	ا	ب	ت	ث	ج	ح	خ	د	ذ	ر	ز	س	ش	ص	ض	ط	ظ	ي	ب	ث	ج	ح	خ	د	ذ	ر	ز	س	ش	ص	ض	ط	ظ	ي
9	ا	ب	ت	ث	ج	ح	خ	د	ذ	ر	ز	س	ش	ص	ض	ط	ظ	ي	ب	ث	ج	ح	خ	د	ذ	ر	ز	س	ش	ص	ض	ط	ظ	ي
A	ا	ب	ت	ث	ج	ح	خ	د	ذ	ر	ز	س	ش	ص	ض	ط	ظ	ي	ب	ث	ج	ح	خ	د	ذ	ر	ز	س	ش	ص	ض	ط	ظ	ي
B	ا	ب	ت	ث	ج	ح	خ	د	ذ	ر	ز	س	ش	ص	ض	ط	ظ	ي	ب	ث	ج	ح	خ	د	ذ	ر	ز	س	ش	ص	ض	ط	ظ	ي
C	ا	ب	ت	ث	ج	ح	خ	د	ذ	ر	ز	س	ش	ص	ض	ط	ظ	ي	ب	ث	ج	ح	خ	د	ذ	ر	ز	س	ش	ص	ض	ط	ظ	ي
D	ا	ب	ت	ث	ج	ح	خ	د	ذ	ر	ز	س	ش	ص	ض	ط	ظ	ي	ب	ث	ج	ح	خ	د	ذ	ر	ز	س	ش	ص	ض	ط	ظ	ي
E	ا	ب	ت	ث	ج	ح	خ	د	ذ	ر	ز	س	ش	ص	ض	ط	ظ	ي	ب	ث	ج	ح	خ	د	ذ	ر	ز	س	ش	ص	ض	ط	ظ	ي
F	ا	ب	ت	ث	ج	ح	خ	د	ذ	ر	ز	س	ش	ص	ض	ط	ظ	ي	ب	ث	ج	ح	خ	د	ذ	ر	ز	س	ش	ص	ض	ط	ظ	ي

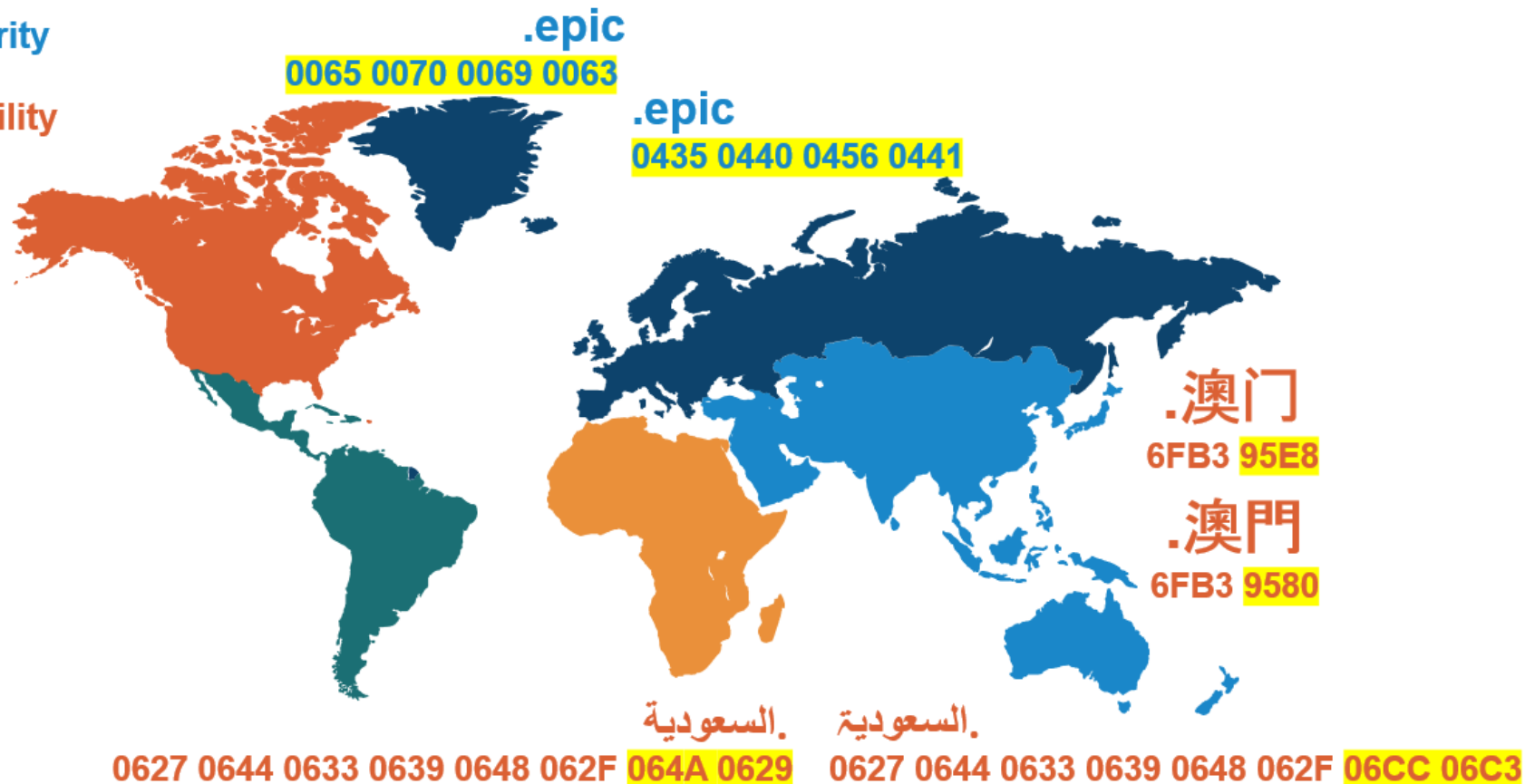
Summary of Community Analysis for Repertoire

Script tag ²⁶	Script Name	MSR-5	LGR-1	LGR-2	LGR-3	LGR-4	LGR-5
Arab	Arabic	241	128	128	128	128	128
Arm	Armenian	38					38
Beng	Bengali	64				62	62
Cyrl	Cyrillic	93					86
Deva	Devanagari	92			84	84	84
Ethi	Ethiopic	364		311	311	311	311
Geor	Georgian	37		33	33	33	33
Gre	Greek	36					36
Gujr	Gujarati	66			65	65	65
Guru	Gurmukhi	61			56	56	56
Hang	Hangul	11 172					11 172
Hani	Han Ideographs	19 855				19 685	19 844
Hebr	Hebrew	46			27	27	27
Hira	Hiragana	89					86
Kana	Katakana	92					88
Khmr	Khmer	78		71	71	71	71
Knda	Kannada	68			62	62	62
Laoo	Lao	53		51	51	51	51
Latn	Latin	312					197
Mlym	Malayalam	73			70	70	70
Mymr	Myanmar	102					99
Orya	Oriya	66			62	62	62
Sinh	Sinhala	79			72	72	72
Taml	Tamil	49			48	48	48
Telu	Telugu	67			63	63	63
Thaa	Thaana	50					
Thai	Thai	71		69	69	69	69
Tibt	Tibetan	80					
Zinh	INHERITED	21					7
Total		33 515	128	663	1 318	21 019	32 987

Understanding Variant TLDs

Code points technically distinct but considered the “same” by the script community
– non-deterministic!

- Security
- Usability



Categories of Variant Code Points - Identical

- ⦿ Visually identical.
 - Same:
 - Armenian, Cyrillic, Greek, Latin: օ օ ֆ ֆ 0585 043E 03BF 006F
 - Japanese: へ へ 3078 30D8
 - Same in a joined form.
 - Arabic:
 - 0643: بکب بکب
 - 06A9: بکب بکب
 - Khmer:
 - ស្ក + ត 179F 17D2 + 178F = ស្កត
 - ស្ក + ដ 179F 17D2 + 178A = ស្កដ

Categories of Variant Code Points - Similar

- ⦿ Similar but not identical.
 - Visually similar:
 - Devanagari and Gurmukhi: ऩ ऩ 0909 0A24
 - Kashmiri vowel signs in Devanagari: ऀ ँ 0973 0905+0902
 - Korean Hangul and Hanja: 슴 슴 C2B4 5408
 - Similar due to cursive/handwriting form:
 - Latin: f *f* 0066 0192
 - Similar with stylistic variation:
 - Arabic: ك ﺔ 06A9 06AA
 - Similar in marks:
 - Latin: ħ ħ 011F 01E7 (breve and caron)

Categories of Variant Code Points – Visually Distinct

- ⊙ Considered equivalent even when not visually similar.
 - Phonetically same or similar:
 - Arabic: ة ة 0647 0629
 - Ethiopic: ህ HA ከ HHA ኀ XA 1200 1210 1280
 - Alternate writing convention:
 - Arabic Western (African) vs. Conventional: ف ق 0642 06A7
 - Chinese Simplified vs. Traditional: 万 萬 4E07 842C
 - Spatial rotation of dots:
 - Arabic: ت ث 062A 067A
 - With or without marks:
 - Greek tonos and dialytica: ι ί ῖ ῖ̂ 03B9 03AF 03CA 0390
 - Contextual variation:
 - Hebrew normal and final form: ף ף 05E4 05E3
 - Semantically same:
 - Chinese: 叢 叢 53E2 6B09

Scripts With Variant Code Points

- Arabic
- Armenian
- Bengali
- Cyrillic
- Devanagari
- Ethiopic
- Georgian
- Greek
- Gujarati
- Gurmukhi
- Han
- Hebrew
- Japanese
- Kannada
- Khmer
- Korean
- Lao
- Latin
- Malayalam
- Myanmar
- Oriya
- Sinhala
- Tamil
- Telugu
- Thaana
- Tibetan
- Thai

	Variant code points
	No variant code points
	Work in progress

Code point variants are as defined in the RZ-LGR - deterministic.
3,763 variant sets in RZ-LGR.

Types of Variant Code Points

- ⦿ Two main types of variant mappings:
 - Blocked – label with a code point with this type cannot be delegated.
 - Allocatable – label with only this type of code points can be considered for delegation.

- ⦿ Design consideration: Maximize blocked variant labels (for end-user security) and minimize allocatable variant labels based on usability (for manageability).
 - Blocked - by default.
 - Allocatable: In few cases, where there is a clear usability requirement documented by the script community.

- ⦿ 58 allocatable and 5,806 blocked variant mappings (excluding CJK).

Label Evaluation Rules

- Context of a character.
 - Complex scripts are inherently rule-based.
 - Different categories of character: consonants, vowels, tone marks, others.
 - In Abugida scripts, there is a specific structure of a well-formed orthographic syllable.
 - Script users apply these rules when writing, and so the same rules are needed when encoding labels.
 - Multiple code point sequences can generate the same orthographic syllable.
 - Out of context code points.
 - Not predicted by users.
 - May not be supported in fonts.
 - May have unpredictable rendering.



Label Evaluation Rules

- Based on the Thai language LGR:
 - The following 2 code points are different vowels:
 - U+0E40 ๒ THAI CHARACTER SARA E
 - U+0E41 ๓ THAI CHARACTER SARA AE
 - Defining a rule to disallow 0E40 to follow itself could reduce the homoglyph confusion with 0E41.



๓ ๓ ๓
U+0E41 U+0E21 U+0E27



๒ ๒ ๓ ๓
U+0E40 U+0E40 U+0E21 U+0E27



Label Evaluation Rules

- ⦿ Context of a character.
 - Lao vowel placement rules:
 - A vowel-before precedes the main consonant cluster C.
 - A vowel-above or a vowel-below follows the main consonant C.
 - A vowel-after follows the main consonant C or a tone mark or a vowel-above.
 - Thai tone mark rule:
 - A tone mark can only follow a consonant, an above-vowel or a below-vowel.
 - Tamil Virama rule:
 - Virama must be preceded by a consonant.

Label Evaluation Rules

- ⦿ Place of a character.
 - Lao repetition sign ເງ (0EC6) can only occur 0-3 times at the end of a label.

- ⦿ Reducing variant labels.
 - Arabic:
 - Cannot mix ﺀ with ﺀ (06C1 with 0647)
 - Cannot mix ﺀ with ﺀ (0629 with 06C3)
 - Myanmar:
 - No mixing from two sets of code points to limit the number of variants generated.

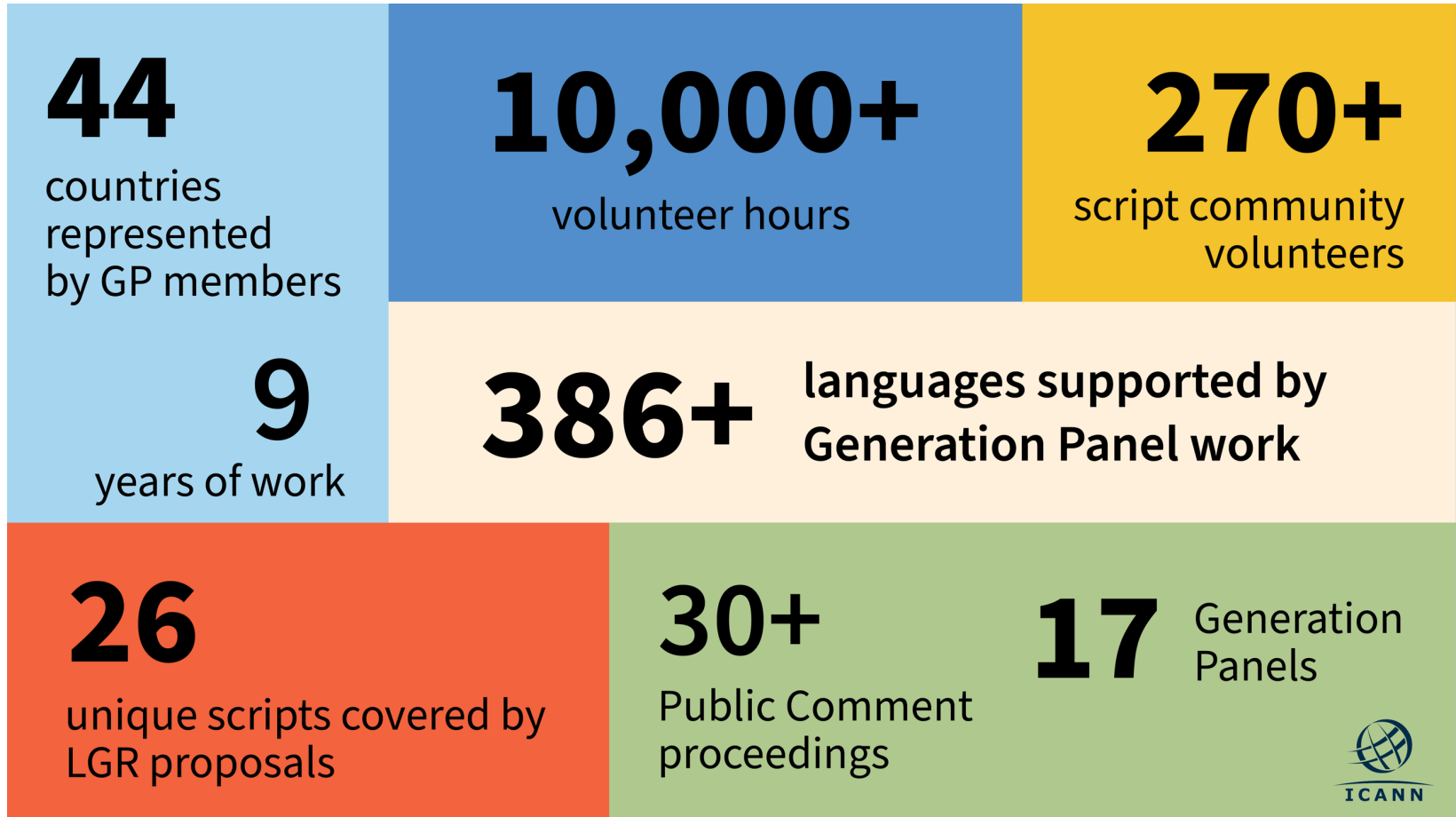
Label Evaluation Rules

- ⊙ The rules fix the order and place of characters to only well-formed and predictable options.
 - Supported by fonts and rendering engines.
- ⊙ The rules also help minimize allocatable variant labels, as needed.
- ⊙ Number of rules 140 for the 26 scripts:
 - Used as context rule - 100.
 - Place of character - 98.
 - Used to trigger actions - 28.
 - Used only in another rule - 14.

Recognizing Community Efforts for RZ-LGR

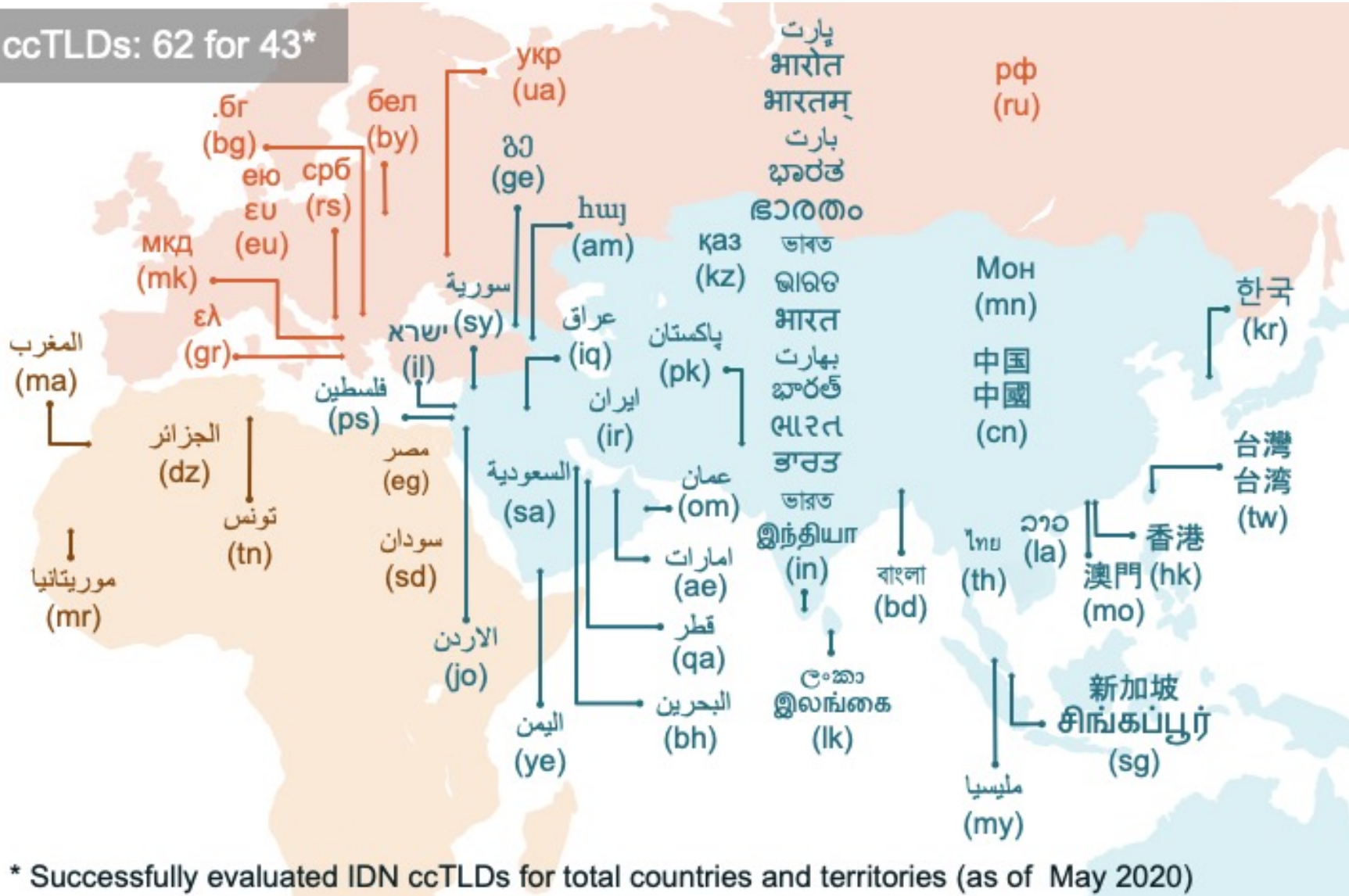
Script	Start	End	Days	2014	2015	2016	2017	2018	2019	2020	2021
Arabic	Feb-14	Nov-15	655								
Armenian	Feb-15	Nov-15	277								
Bengali	May-15	May-20	1846								
Chinese	Sep-14	May-20	2094								
Cyrillic	Dec-15	Apr-18	854								
Devanagari	May-15	Apr-19	1452								
Ethiopic	Dec-15	May-17	533								
Georgian	Jun-16	Nov-16	176								
Greek	Oct-16	Jul-21	1748								
Gujarati	May-15	Mar-19	1405								
Gurmukhi	May-15	Apr-19	1452								
Hebrew	Oct-18	Apr-19	205								
Japanese	Mar-15	Sep-21	2376								
Kannada	May-15	Mar-19	1405								
Khmer	Jun-15	Aug-16	441								
Korean	Feb-16	May-21	1916								
Lao	Sep-15	Jan-17	518								
Latin	May-17	Sep-21	1606								
Malayalam	May-15	Jun-20	1883								
Myanmar	Jun-18	Mar-22	1385								
Oriya	May-15	Mar-19	1405								
Sinhala	Jan-18	Apr-19	476								
Tamil	May-15	Mar-19	1405								
Telugu	May-15	Jun-19	1498								
Thaana											
Thai	Oct-15	May-17	602								
Tibetan											

Recognizing Community Efforts for RZ-LGR



IDN Country Code Top-Level Domains (ccTLDs)

ccTLDs: 62 for 43*



* Successfully evaluated IDN ccTLDs for total countries and territories (as of May 2020)

Examples of IDNs

1. համընդհանուր-ընկալում-թեքստ.հայ Armenian
2. മുൻ‌കരുതൽ-വകുപ്പ്-റേഷ.ଭାରତ Oriya
3. უნივერსალური-თავსობადობის-ტესტი.გე Georgian
4. 다국어도메인이용환경테스트.한국 Korean
5. സാർവത്രിക-സ്വീകാര്യതാ-പരിശോധന.ഭാരതം Malayalam
6. تجربة-القبول-الشامل.موريتانيا Arabic

Examples of Internationalized Email

1. Էլփոստ-թեստ@համընդհանուր-ընկալում-թեստ.հայ Armenian
2. 电子邮件测试@普遍适用测试.我爱你 Chinese
3. ईमेल-परीक्षण@सार्वभौमिक-स्वीकृति-परीक्षण.संगठन Devanagari
4. تجربة-بريد-الالكتروني@تجربة-القبول-الشامل.موريتانيا Arabic
5. ηλεκτρονικό-μήνυμα-δοκιμή@καθολική-αποδοχή-δοκιμή.ευ Greek
6. மின்னஞ்சல்-சோதனை@பொது-ஏற்பு-
சோதனை.சிங்கப்பூர் Tamil

Conclusions for RZ-LGR

- ⦿ [RZ-LGR](#) available online along with detailed [Supporting Documents](#).
- ⦿ Creates a solution for top-level domains in multiple scripts and languages, balancing different design principles while being sufficiently conservative.
- ⦿ Developed by the relevant script community with expertise of the script.
 - Includes the repertoire needed for common and general-purpose use.
 - Gives a deterministic definition of variant labels.
 - Allows for domain names which are well-formed for the community.
- ⦿ Provides a solution which is technically viable and secure for the end-users.
 - Repertoire.
 - Variant labels.
 - Context rules.
- ⦿ Enables a solution which addresses the usability of domain names.

Conclusions for RZ-LGR

- ⊙ Provides a solution which can evolve in a stable manner (e.g., adding support of more languages and scripts).
- ⊙ ICANN has enabled an LGR Tool to develop and use RZ-LGR; available open source – visit www.icann.org/idn.
- ⊙ Developing reference LGRs for second level registrations, including digits and hyphen, as needed.
 - For second-level reference LGRs also working on scripts categorized as “Limited Use” by Unicode in UAX#31.
- ⊙ LGRs have a potential use beyond domain names, where Unicode based unique identifiers are needed, e.g., managing mailbox names in internationalized email addresses, font design, etc.

Engage with ICANN



Thank You and Questions

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