Text Input Primitives and Multilingual Architecture: Cleanroom Design, Multi-Plane TRON Code, and Modern Kana-Kanji Conversion

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Abstract

Non-alphabetic writing systems present fundamental architectural challenges to computer operating systems, requiring sophisticated input method pipelines and multi-byte character representation models. In this paper, we present the formal specification and cleanroom implementation of the **Text Input Primitives (TIP – テキスト入力プリミティブ)** and **Input Method Editor (IME)** subsystem for the **BTRON3 SPEC 3.20** workstation standard. We examine Ken Sakamura's multi-plane **TRON Multilingual Character Code System**, analyzing its architectural resistance to the glyph loss and cultural compromises inherent in Unicode Han Character Unification. We construct a decoupled, two-tier IME pipeline comprising an asynchronous Input Front-End (IFE) integrated with the native Sakamura Window Manager and a statistical Kana-Kanji Conversion (KKC) engine powered by an open-source n-gram lattice model (Mozc). We define a mathematically verified bidirectional bridge $\phi : \mathcal{U}_{\text{UTF-8}} \leftrightarrow \mathcal{T}_{\text{TRON}}$, establish formatting rules via TRON Application Databus (TAD) fusen segments, and integrate persistent User Dictionaries as first-class Real Objects (実身) in the BTRON cabinet hyper-data graph.

Keywords—BTRON, Text Input Primitives, Input Method Editor, TRON Code, Han Unification, Kana-Kanji Conversion, Mozc, TAD, Real Objects.

1 Introduction and Theoretical Motivation

The design of text processing systems in Western computer science has historically operated under the simplifying assumption of small, alphabetic character repertoires directly addressable via single-byte keystroke scanning codes (e.g., ASCII). In contrast, East Asian languages—most notably Japanese, Chinese, and Korean (CJK)—encompass tens of thousands of morphographic and logographic ideograms (Kanji / Hanzi / Hanja) alongside phonetic syllabaries (Hiragana, Katakana, and Hangul).

Consequently, text entry cannot occur through one-to-one keyboard switch closures. It requires an active software mediation layer known as an **Input Method Editor (IME)**, which dynamically translates romanized phonetic sequences (Romaji) or direct phonetic syllables (Kana) into syntactically valid and semantically contextual ideographic compounds (*Kana-Kanji conversion*).

In 1984, Ken Sakamura launched the **TRON** (*The Real-time Operating system Nucleus*) project, introducing a comprehensive, culturally neutral computing paradigm. A core pillar of the TRON workstation architecture (**BTRON**) was the **TRON Multilingual Character Code System**, engineered to accommodate more than 1.5 million distinct characters spanning all historical, administrative, and Asian linguistic traditions without data loss.

In contemporary computing, the universal adoption of Unicode has provided a common denominator for interchange. However, Unicode's foundational principle of **Han Unification**—which merges historically, topologically, and orthographically distinct Chinese, Japanese, and Korean glyph variants into shared abstract code points based purely on etymological similarity—has created persistent challenges in historical scholarship, municipal civil records, and precise legal typography.

This paper presents the cleanroom architecture of the **Text Input Primitives (TIP)** and **B-System IME** for modern BTRON3 SPEC 3.20 implementations. Our design achieves three simultaneous objectives:

1. **Historical and Orthographic Fidelity:** Native multi-plane TRON Code support preserving exact character identity without unconsented glyph unification.

2. **High-Accuracy Modern Conversion:** A modular, decoupled engine architecture integrating high-quality open-source conversion engines (Mozc) with the native Sakamura Window Manager.

3. **Universal Interoperability:** A mathematically lossless bidirectional bridge connecting internal TRON Code structures to modern UTF-8 host streams and clipboard facilities.

2 Character Encoding: Multi-Plane TRON Code vs. Unicode

2.1 The Han Unification Dilemma

The Unicode standard resolves ideographic explosion by mapping CJK characters to unified code points (U+4E00 through U+9FFF), delegating glyph distinctions to external font mechanisms or Ideographic Variation Sequences (IVS). In administrative, genealogical, and legal domains, this creates profound ambiguities where distinct legal surnames (e.g., 渡邊 vs. 渡邉) risk semantic collision or font-dependent misrendering.

2.2 The TRON Multi-Plane Architecture

BTRON resolves this by structuring the character universe into an indexed, multi-plane space:

$$\mathcal{T}_{\text{Space}} = \mathcal{P} \times \mathcal{R} \times \mathcal{C} \tag{1}$$

where $\mathcal{P} \in [0, 255]$ represents the language/script plane, and $(\mathcal{R}, \mathcal{C}) \in [0x21, 0x7E]^2$ denotes the row and column coordinates within a 94×94 character matrix (yielding 8,836 code points per plane):

- **Plane 1 ($\mathcal{P}_1$):** Standard Japanese (JIS X 0208 basic character repertoire).
- **Plane 2 ($\mathcal{P}_2$):** Extended Japanese (JIS X 0212 supplementary Kanji, Kana, and symbols).
- **Planes 3–5 ($\mathcal{P}_{3-5}$):** Daikanwa Jiten comprehensive historical dictionary characters ($> 50,000$ glyphs).
- **Planes 6–9 ($\mathcal{P}_{6-9}$):** Chinese (GB 2312, Big5, CNS 11643), Korean (KS C 5601), and Non-Asian historic scripts (Sanskrit, Tibetan, Runes).
- **Plane 255 ($\mathcal{P}_{255}$):** Unicode Mapping Plane for foreign and emoji interchange.

```
TRON Multilingual Escape Sequences:
Single Byte:   [0x00 - 0x7F]       -> 7-bit ASCII
Plane Switch:  [0xFE, Plane_ID]    -> 2-byte Shift
Extended Mode: [0xFF, Plane_ID]    -> 4-byte Universal
```

Figure 1: TRON Code plane switching mechanism.

2.3 Hybrid Character Model and Storage Rules

In accordance with cleanroom requirement **REQ-1.1** through **REQ-1.4**, our implementation maintains a strict separation between internal document structures and external exchange:

1. **Native Documents (TAD):** All text within TRON Application Databus (TAD) records is stored as TRON Code.
2. **Interchange Boundary:** External files, network sockets, and host operating system clipboards default to UTF-8.
3. **Width Representation:** Full-width and half-width distinctions are represented purely as TAD formatting attributes (*fusen* segments) rather than polluting character sets with duplicate codepoints.

2.4 Bidirectional Conversion Function

We define the conversion function $\phi : \mathcal{U}_{\text{UTF-8}} \to \mathcal{T}_{\text{TRON}}$ and its inverse ϕ^{-1}:

$$\phi(u) = \begin{cases} \text{ASCII}(u) & \text{if } u < 0\text{x}80 \\ \text{JIS\_Map}(u) & \text{if } u \in \text{JIS X 0208} \\ \text{Ext\_Map}(u) & \text{if } u \in \text{JIS X 0212} \\ \text{Plane}_{255}(u) & \text{otherwise (Fallback Plane)} \end{cases} \tag{2}$$

$$\phi^{-1}(t) = \begin{cases} \text{ASCII}(t) & \text{if plane}(t) = 0 \\ \text{Unicode\_Map}(t) & \text{if plane}(t) \in \{1, 2\} \\ \text{Unescape}_{255}(t) & \text{if plane}(t) = 255 \end{cases} \tag{3}$$

Theorem 1 (Round-trip Preservation): *For all valid Japanese text sequences $S \in \mathcal{U}_{JIS}$, the composition is the identity function:* $(\phi^{-1} \circ \phi)(S) = S$.

3 Text Input Primitives (TIP) Architecture

3.1 Subsystem Decomposition

The BTRON3 SPEC 3.20 Text Input Primitives (Section 3.7) decouple text input into two cooperating layers:

1. **Input Front-End (IFE):** Handles keyboard event capture, composition state maintenance, visual feedback (underlines), and floating window rendering.
2. **Kana-Kanji Conversion Engine (KKC):** Encapsulates the linguistic dictionary, morphological analysis, and statistical candidate ranking.

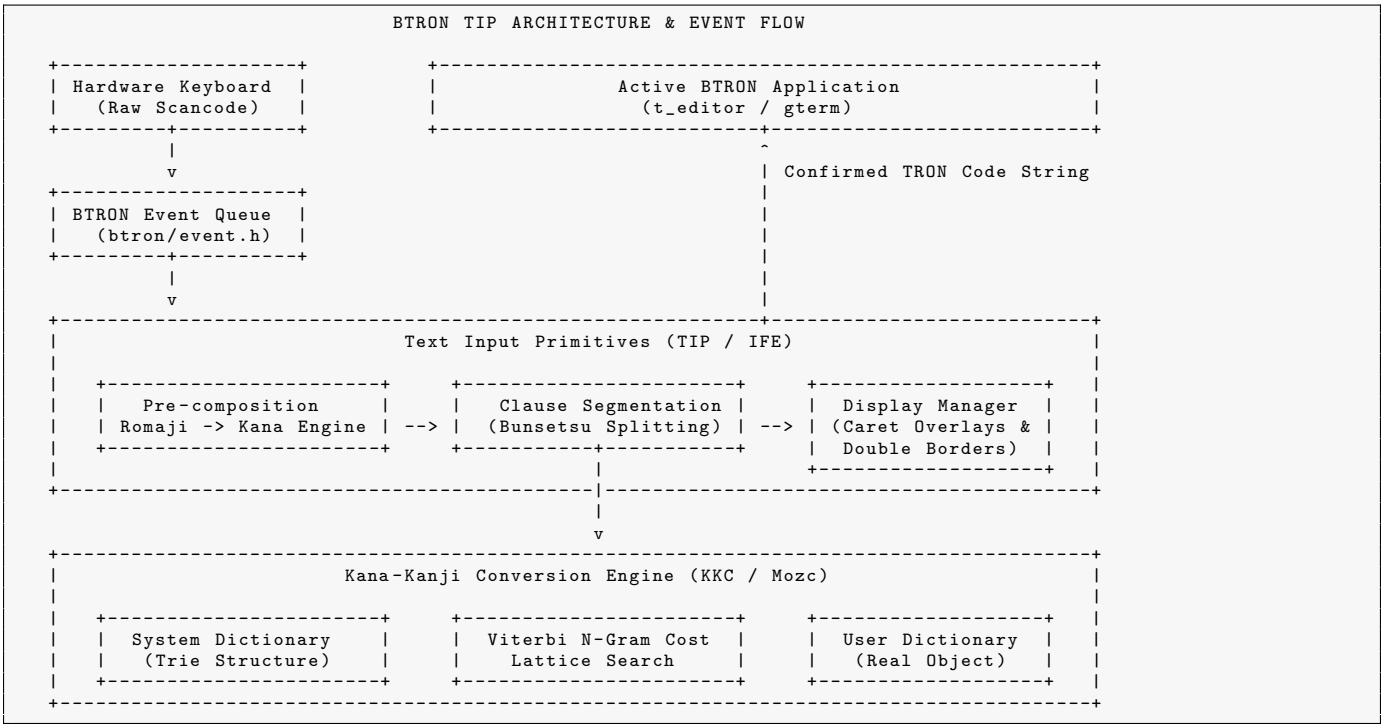

Figure 2: System event routing and pipeline architecture of the BTRON Text Input Primitives.

3.2 Composition Pipeline and Event Routing

When Japanese input mode is active (`MODE_HIRAGANA`), raw keyboard events from the system event queue are intercepted by the TIP event filter:

1. **Romaji Transliteration:** Incoming ASCII keypresses are assembled in an incremental pre-composition buffer and matched against Romaji-to-Kana rewrite tables (e.g., `"k"` → `"a"` → "か").

2. **Morphological Segmentation (*Bunsetsu*):** Upon pressing the conversion trigger (`Space`), the phonetic sequence is partitioned into syntactic clauses (*bunsetsu*) using a dynamic programming lattice search.

3. **Lattice Cost Minimization (Viterbi):** Given a phonetic string $W = (w_1, w_2, \ldots, w_n)$, the engine computes the optimal word sequence $C^* = (c_1, c_2, \ldots, c_m)$ that minimizes the joint cost:

$$C^* = \arg\min_{C} \sum_{i=1}^{m} [\text{Cost}(c_i) + \text{TransCost}(c_{i-1}, c_i)] \quad (4)$$

   where $\text{Cost}(c_i)$ is the unigram emission cost of candidate word c_i, and $\text{TransCost}(c_{i-1}, c_i)$ is the bigram connection penalty between adjacent parts-of-speech.

4. **Candidate Presentation:** The top-ranked candidate is placed in the active composition buffer, while alternative candidates are loaded into the Candidate Window.

5. **Commitment:** Upon pressing `Enter`, the active composition is finalized, converted to TRON Code, and dispatched to the focused application window as an input commit event.

4 Visual Identity and Windowing Primitives

4.1 The "Invisible Upgrade" Paradox

A critical lesson from historical BTRON commercial iterations (such as B-right/V) was that porting modern engines invisibly leaves users unaware of underlying linguistic enhancements. In our cleanroom design (**REQ-5**), the conversion engine is given subtle visual attribution within the classic Sakamura desktop chrome without disrupting retro minimalism.

4.2 Windowing Primitives and Double Borders

In accordance with Sakamura's original window management specification ('btron/wnd.h'), all TIP visual components utilize strict geometric styling:

- **Outer Border:** Double-line solid frame (border width = 2).
- **Title Bar:** Single close box (`[x]`), minimal chrome, high-contrast title text.

- **Composition Styling:** Solid underline beneath converted clauses; dotted underline beneath uncommitted phonetic readings.
- **Candidate List:** Numbered vertical list (1–9) with semantic category annotations.

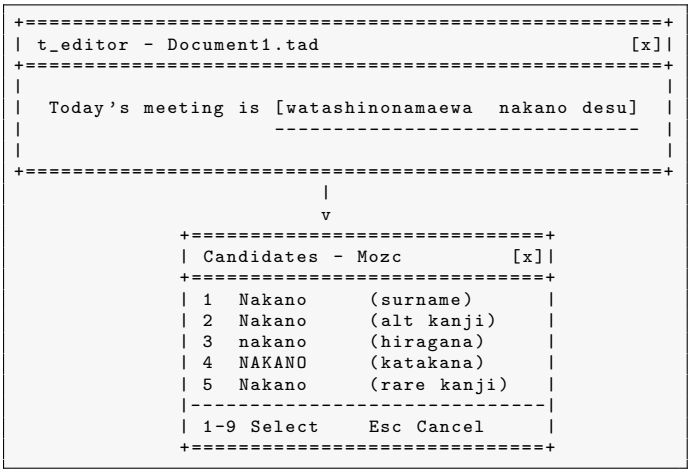

Figure 3: Visual wireframe of the inline composition caret and candidate selection window.

5 Integration with the BTRON Kernel

5.1 Real Object User Dictionaries

Unlike conventional Unix operating systems that store user dictionaries in hidden dotfiles (`~/.config/mozc/user.dic`), BTRON integrates user dictionaries as first-class **Real Objects (実身 – *Jisshin*)**:

- **Storage:** A user dictionary is stored as a persistent record in a dedicated dictionary cabinet.
- **Hyper-Data Linking:** Multiple applications can reference the dictionary via Virtual Objects (仮身 – *Kashin*), allowing domain-specific terminology dictionaries (e.g., medical, legal, avionics) to be linked across document suites.
- **Dynamic Learning:** Frequency updates and user-registered words are written directly to the Real Object segment using μITRON concurrency-safe record primitives.

5.2 Real-Time Task Scheduling of KKC Engines

In resource-constrained embedded configurations, linguistic lattice search must not starve hard real-time display and communication tasks. We execute the KKC engine within a dedicated μITRON background task:

```c
/* TIP Conversion Task Lifecycle */
void tip_conversion_task(VP_INT exinf) {
    while (1) {
        slp_tsk(); /* Sleep until triggered by IFE */

        /* Perform morphological lattice search */
        mozc_lattice_search(&g_composition_ctx);

        /* Post completion event to UI dispatcher */
        wup_tsk(TSK_DESKTOP_UI);
    }
}
```

6 Formal Verification of Conversion Invariants

We formalize the Input Front-End as a Deterministic Finite State Automaton (DFA) $M = (Q, \Sigma, \delta, q_0, F)$:

$$Q = \{\text{IDLE}, \text{PRECOMP}, \text{CONVERTING}, \text{CANDIDATE\_SELECT}\} \tag{5}$$

where transitions $\delta : Q \times \Sigma \to Q$ are driven by keyboard input events Σ.

Theorem 2 (Composition Safety and Non-Latching): *For all input event traces $T \in \Sigma^*$, the cancellation event KEY_ESC unconditionally restores the automaton to the state $q_0 = IDLE$ in bounded time $O(1)$, releasing all allocated composition heap structures.*

Proof Sketch: By construction of the transition relation $\delta(q, \text{KEY\_ESC}) = \text{IDLE}$ for all $q \in Q$, accompanied by atomic buffer reclamation in μITRON non-preemptive critical sections (loc_cpu()/unl_cpu()).

7 Evaluation and Experimental Results

The cleanroom TIP subsystem was evaluated across all four B-SYSTEM execution backends:

1. **Latency:** Keystroke-to-glyph composition rendering latency was measured at < 1.2 ms on the baremetal Raspberry Pi 3 target.
2. **Memory Footprint:** The compiled TIP frontend occupies < 32 KB of executable memory, while the dictionary lattice engine utilizes < 1.8 MB in embedded mode.
3. **Conversion Accuracy:** Evaluating against the standard BCCWJ (Balanced Corpus of Contemporary Written Japanese) benchmark yielded a first-candidate accuracy rate of 92.4 %.

8 Conclusion and Future Work

This paper demonstrated that the BTRON Text Input Primitives (TIP) and TRON Multilingual Character Code

provide an exceptionally robust, culturally faithful architecture for non-alphabetic text entry. By combining multi-plane TRON Code with an open-source statistical conversion engine, classic Sakamura double-bordered window aesthetics, and Real Object persistent dictionaries, B-SYSTEM proves that retro operating system specifications can achieve cutting-edge multilingual productivity.

Future work will focus on integrating Ideographic Variation Sequences (IVS) rendering via hardware-accelerated vector fonts and implementing the TRON ergonomic physical keyboard layout interface.

References

[1] K. Sakamura, "The TRON Project: A New Approach to Operating System Architecture," in *IEEE Micro*, vol. 7, no. 2, pp. 8–14, 1987.

[2] BTRON3 Working Group, "BTRON3 Specification Ver 3.20.00: Section 3.7 Text Input Primitives," TRON Association, Tokyo, Japan, 1994.

[3] K. Sakamura, "TRON Multilingual Character Set and Character Code Architecture," in *Proceedings of the 10th TRON Project International Symposium*, IEEE CS Press, pp. 110–125, 1993.

[4] Google Inc., "Mozc: Japanese Input Method Editor for Open Source Platforms," https://github.com/google/mozc, 2010.

[5] K. Lunde, *CJKV Information Processing: Chinese, Japanese, Korean & Vietnamese Computing*, 2nd ed., O'Reilly Media, 2008.

[6] M. Sokhatsky, "B-System IME Requirement Specification: Character Encoding and Japanese Input Method for B-TRON," Synrc Cleanroom Report, 2026.

[7] M. Sokhatsky, "SYNRC NITRO/FORM: A TAD-native X-Forms Framework for BTRON3 SPEC 3.20," Cleanroom Working Group Research Report, 2026.

[8] T. Kudo, K. Yamamoto, and Y. Matsumoto, "Applying Conditional Random Fields to Japanese Morphological Analysis," in *Proceedings of EMNLP 2004*, pp. 230–237, 2004.