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Tolerance for Errors in Authentication of Pervasive Services

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THE PROBLEM

Why typos cost security

Passwords are the dominant means of authentication for pervasive services. Although strong ones impose a high cognitive load, they are hard to remember and to type. A frequent frustration is a login **rejected over a single minor typo.** Users react with security-degrading habits, such as reusing, shortening, or writing passwords down, leaving accounts open to dictionary attacks.

OUR APPROACH

Confidence-gated correction

Allow a limited number of typing errors, **but only when behavioural biometrics are confident it is really you.** That confidence comes from keystroke dynamics: a non-intrusive, software-only biometric. Because biometrics give convenience but not security (they can be observed and copied), we pair them with standard hashing, an error-correcting code repairs a confidence, limited number of symbols, then the result is checked against the stored password hash.

HOW IT WORKS

From keystroke to login

1. Enter credentials; a keystroke-dynamics sample is recorded while typing.
2. Server extracts features → biometric query, matched to the template → confidence ***c***.
3. Confidence ***c*** sets a Reed–Solomon budget ***t***; otherwise correction is skipped.
4. Repair up to ***t*** symbols, then run the normal password-hash check.

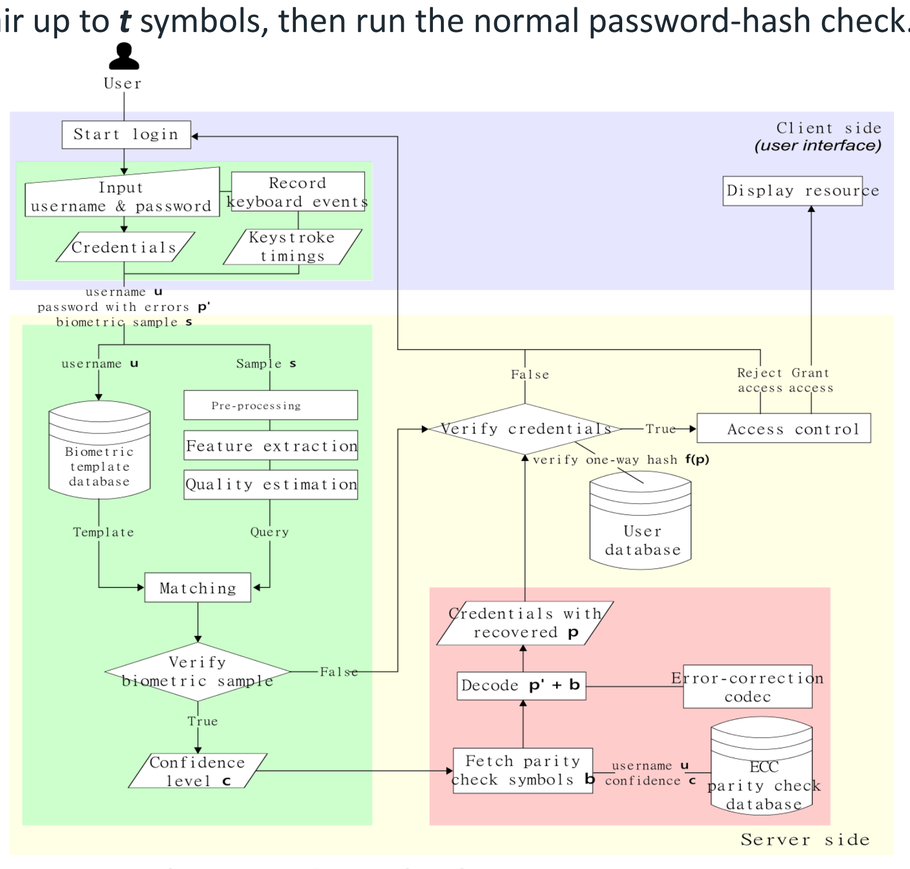


Figure 1: Keystroke dynamics features and Process flow for the proposed error-tolerant authentication system prototype. The client (purple) only records keystroke timing; the server verifies the keystroke biometric (green) and applies confidence-gated Reed–Solomon error-correction (red) before the ordinary one-way-hash check. Low confidence skips correction, leaving normal login unchanged.

KEYSTROKE DYNAMICS

Typing rhythm as a biometric

Everyone types with a habitual rhythm. From the password we extract **dwell-time, flight-time and intervals** into a timing vector. For a length-*n* password, that gives n dwell-times and *n−1* of each other feature. The vector is compared with a per-user template (the mean and standard deviation of recent samples).

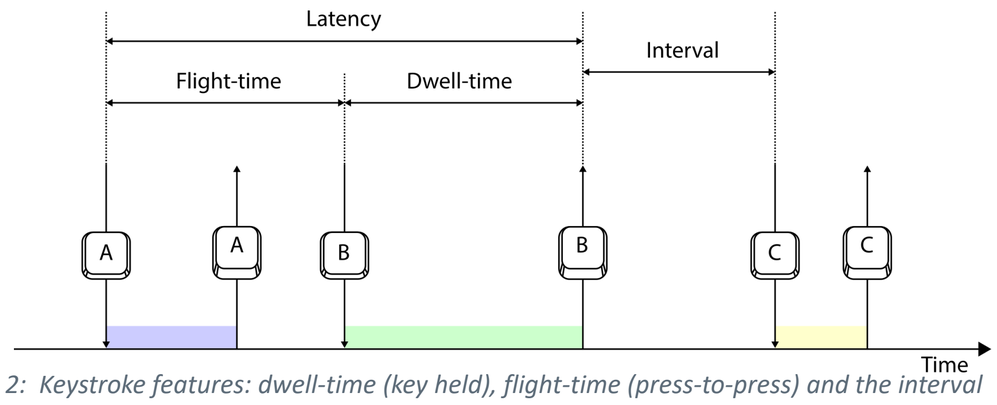


Figure 2: Keystroke features: dwell-time (key held), flight-time (press-to-press) and the interval between release and next press, from key-press / -release events.

Classifier	Equal Error Rate
Normalized Euclidean	24.62%
Gaussian distribution *best*	13.81%
Nonlinear	23.53%

Thresholds set at the Equal Error Rate; a sliding window of the 10 latest error-free samples adapts the template to drift.

ERROR CORRECTION

Reed–Solomon repair

Each password is encoded into Reed–Solomon code-words of increasing capacity t, and the biometric confidence selects which t to apply. Real typos are small: **88.9% of wrong passwords are within three edits** (Levenshtein), and 64.2% within three substitutions (Hamming). Correction cuts rejected logins by 42% at $t = 1$, 55% at $t = 2$ and 61% at $t = 3$.

SECURITY TRADE-OFF

Longer, stronger passwords

Correcting *k* of *n* symbols shrinks the password space from m^n to $C(n,k)\cdot m^{n-k}$, a small cost best reinvested in **length.** A 13-character password forgiving two typos matches the usability of a plain 7-character one, while being far stronger. Fuzzy cryptography stores hashes, not raw typing patterns.

CONCLUSION

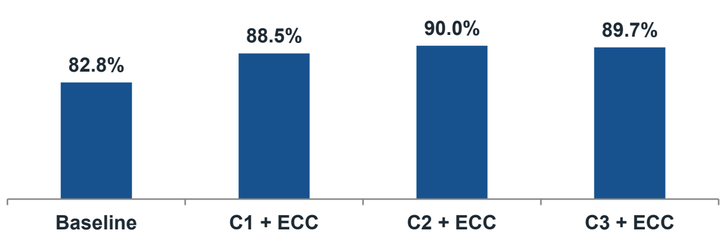
What it delivers

- Recovers about one third of rejected logins with no loss of security.
- Enables longer, stronger passwords at equal convenience.
- Extends to pattern-unlock; future work: multimodal confidence and password-drift correction.

RESULTS — 2,520 AUTHENTICATION EVENTS · 28 PARTICIPANTS · 7 DAYS

Login success rate

Successful logins rise from 82.8% to 90.0% (Gaussian + ECC).

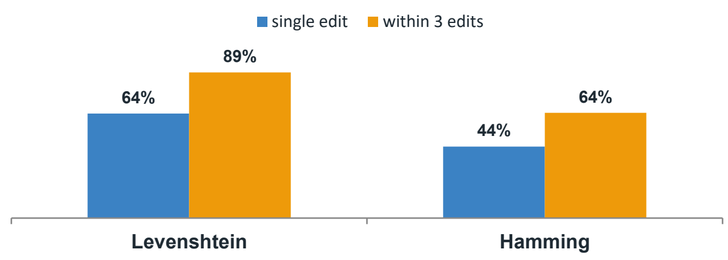


Fewer rejections as *t* grows

Rejected genuine logins drop as the budget t increases.

Error magnitudes

Typos repairable within one and within three edits.



Full paper