File Synchronization from Insertions and Deletions

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Joint work with:
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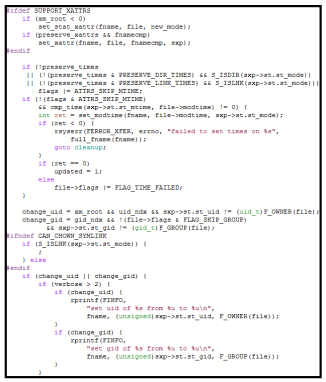
CoDESS Kickoff Meeting
Sept. 19th, 2013

Motivation

Original File



```
#ifdef SUPPORT_XATTRS
    if (am_root < 0)
        set_stat_xattr(fname, file, new_mode);
    if (preserve_xattrs && fnamecmp)
        set_xattr(fname, file, fnamecmp, sxp);
#endif

    if (!preserve_times
     || (!(preserve_times & PRESERVE_DIR_TIMES) && S_ISDIR(sxp->st.st_mode))
     || (!(preserve_times & PRESERVE_LINK_TIMES) && S_ISLNK(sxp->st.st_mode)))
        flags |= ATTRS_SKIP_MTIME;
    if (!(flags & ATTRS_SKIP_MTIME)
     && cmp_time(sxp->st.st_mtime, file->modtime) != 0) {
        int ret = set_modtime(fname, file->modtime, sxp->st.st_mode);
        if (ret < 0) {
            rsyserr(FERROR_XFER, errno, "failed to set times on %s",
                    full_fname(fname));
            goto cleanup;
        }
        if (ret == 0)
            updated = 1;
        else
            file->flags |= FLAG_TIME_FAILED;
    }

    change_uid = am_root && uid_ndx && sxp->st.st_uid != (uid_t)F_OWNER(file);
    change_gid = gid_ndx && !(file->flags & FLAG_SKIP_GROUP)
        && sxp->st.st_gid != (gid_t)F_GROUP(file);
#ifndef CAN_CHOWN_SYMLINK
    if (S_ISLNK(sxp->st.st_mode)) {
        ;
    } else
#endif
    if (change_uid || change_gid) {
        if (verbose > 2) {
            if (change_uid) {
                rprintf(FINFO,
                        "set uid of %s from %u to %u\n",
                        fname, (unsigned)sxp->st.st_uid, F_OWNER(file));
            }
            if (change_gid) {
                rprintf(FINFO,
                        "set gid of %s from %u to %u\n",
                        fname, (unsigned)sxp->st.st_gid, F_GROUP(file));
            }
        }
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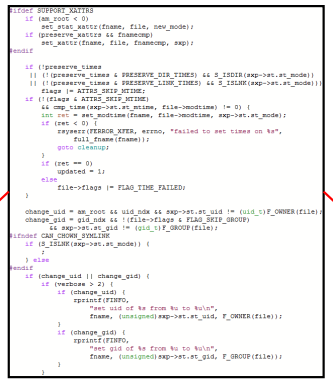

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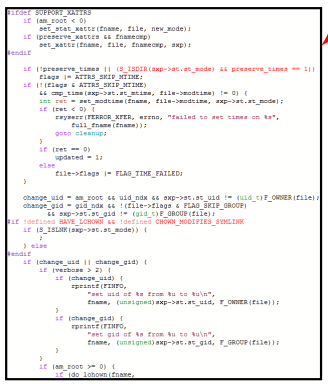

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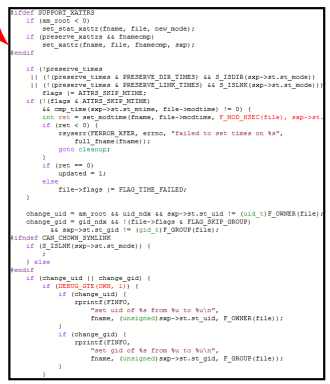

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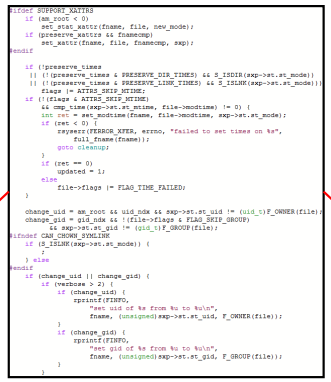

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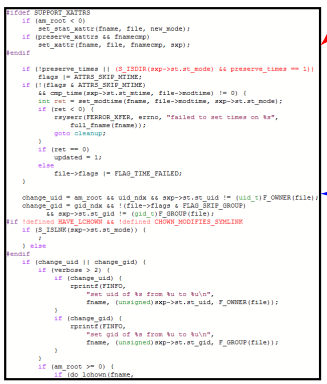

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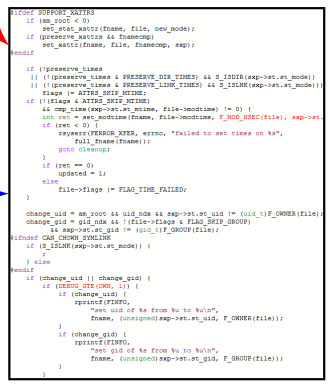

Synchronization Protocol

so that Bob's version matches Alice's

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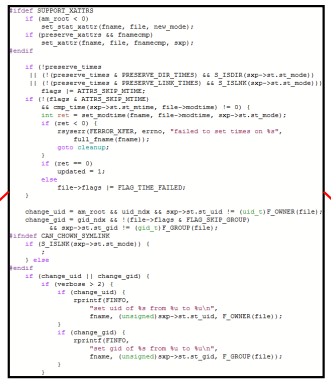

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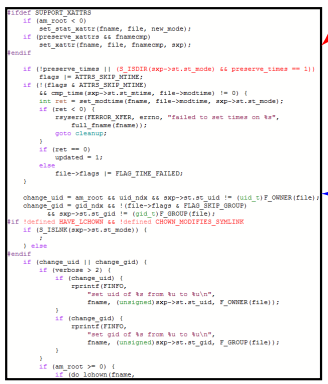

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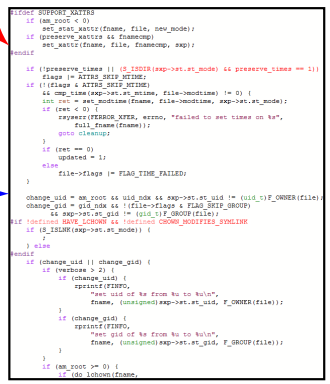

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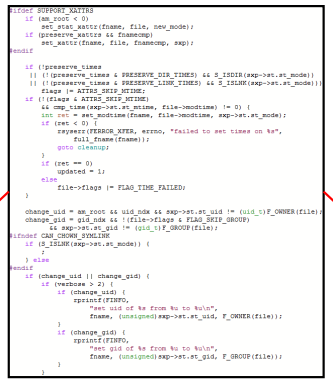

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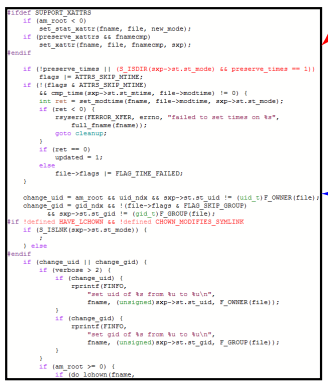

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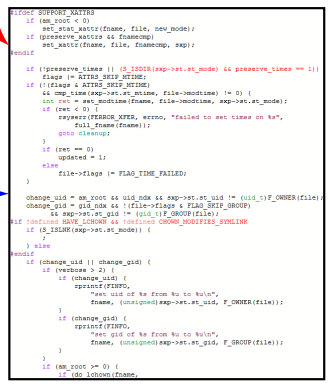

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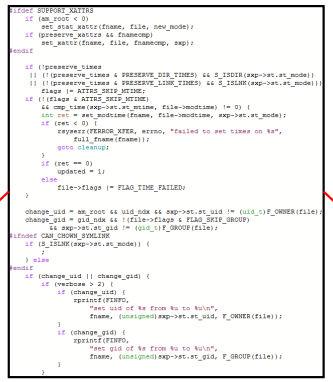

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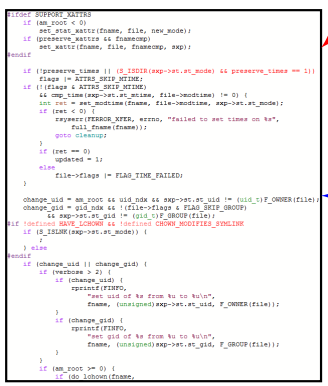

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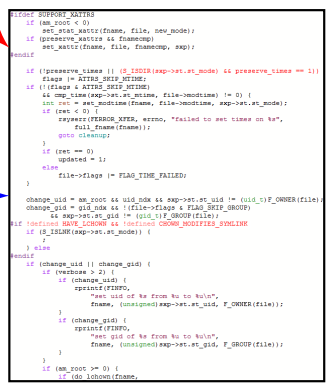

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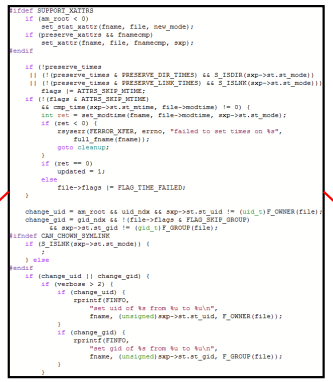

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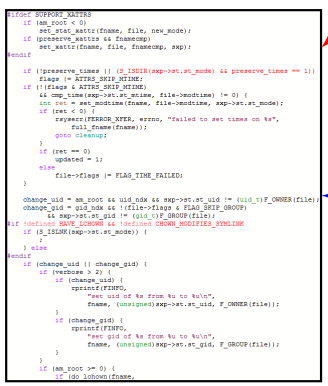

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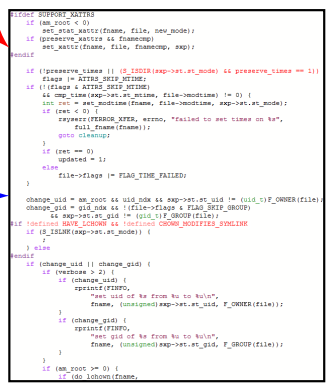

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Problem Setting

File X: h d c e a t g b k u j r v c x f q...

File Y: h d e a k t g v b j r v c r f s q...

Small rate of edits:
Each symbol is edited with probability $\beta \ll 1$.

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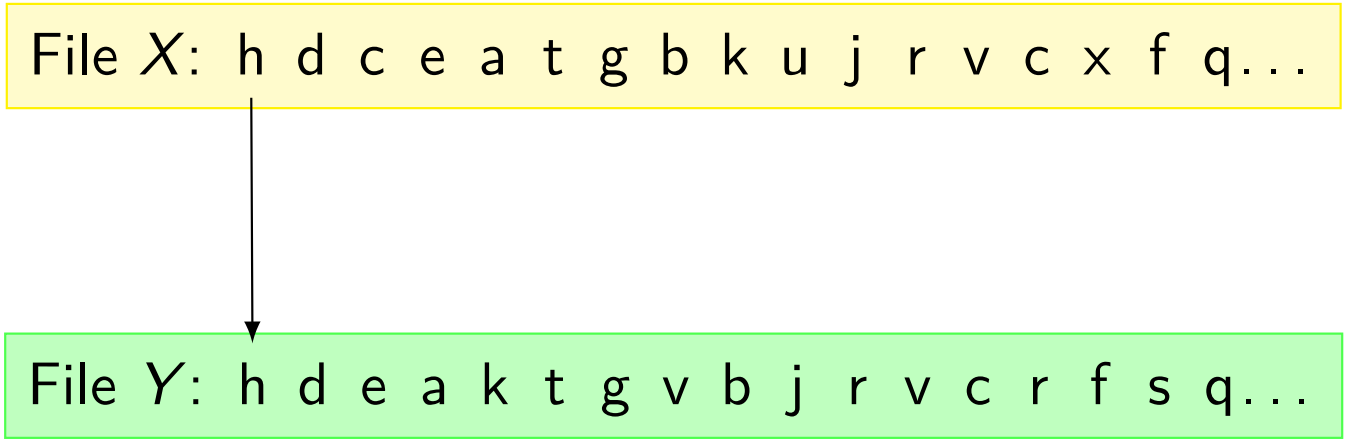

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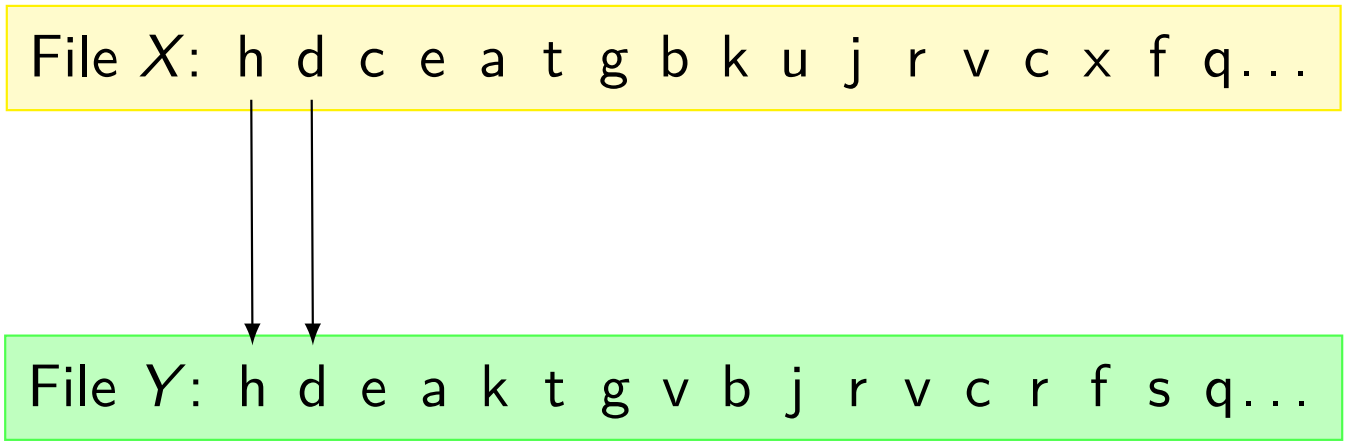

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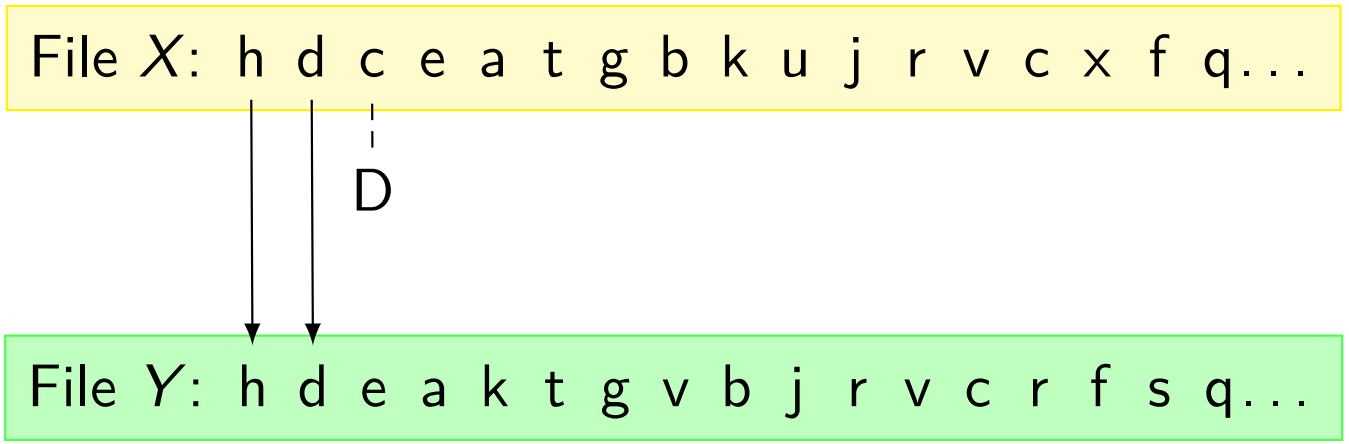

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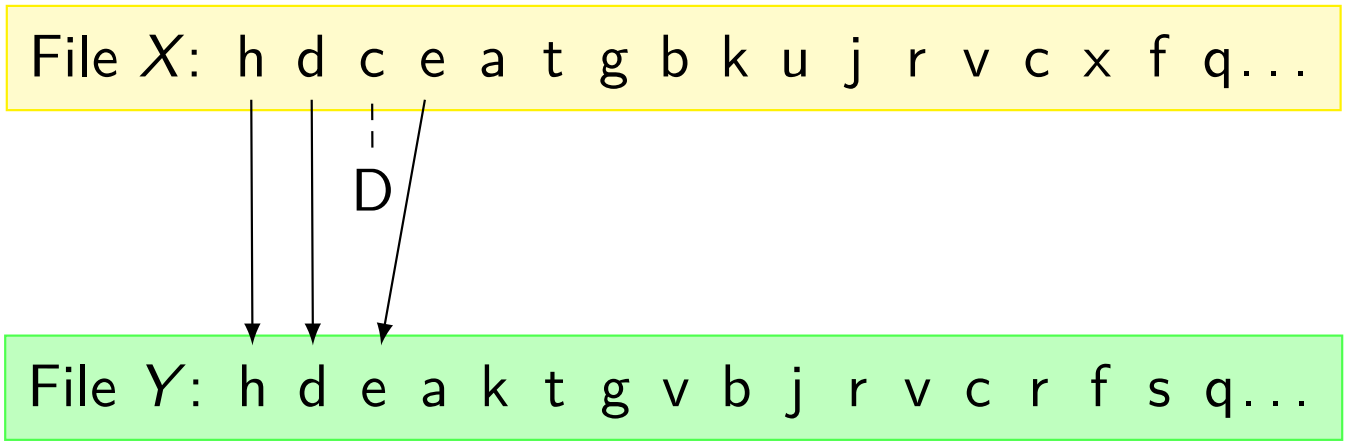

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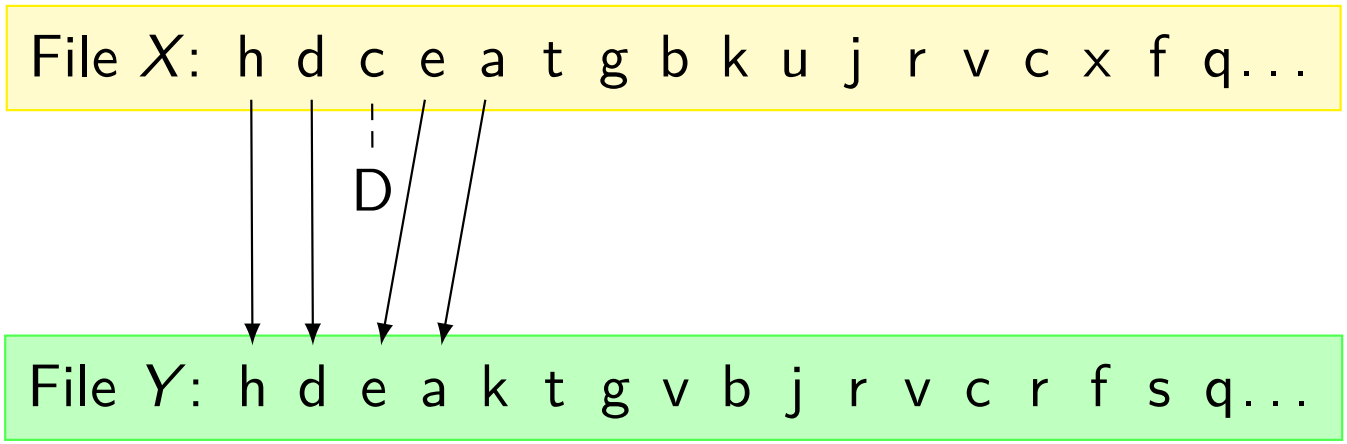

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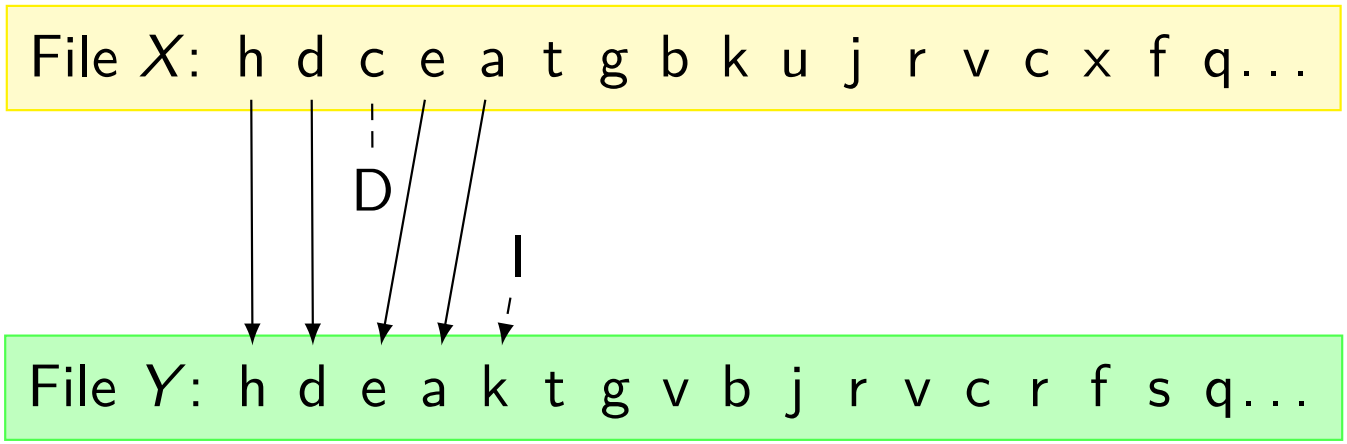

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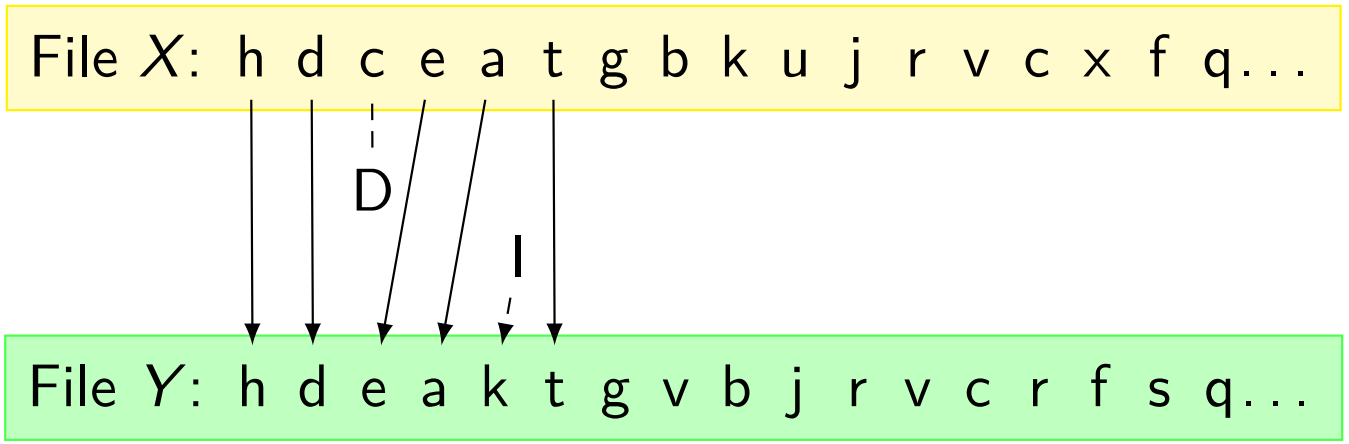

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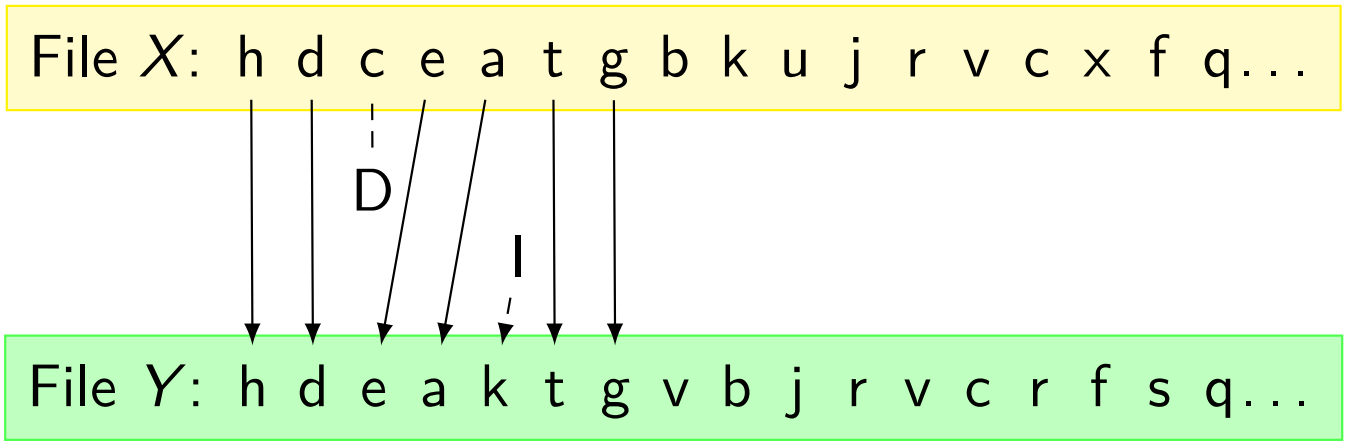

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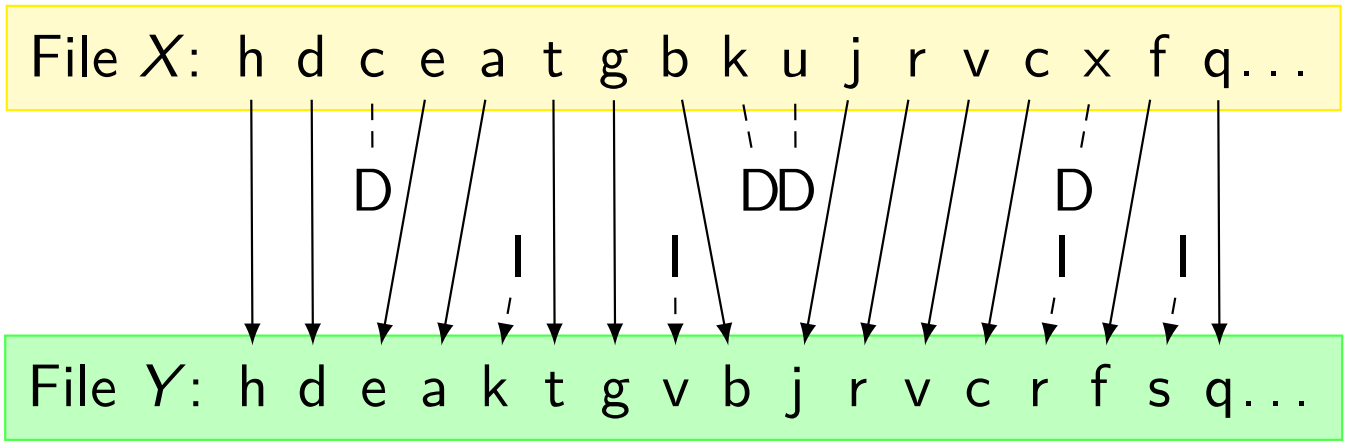

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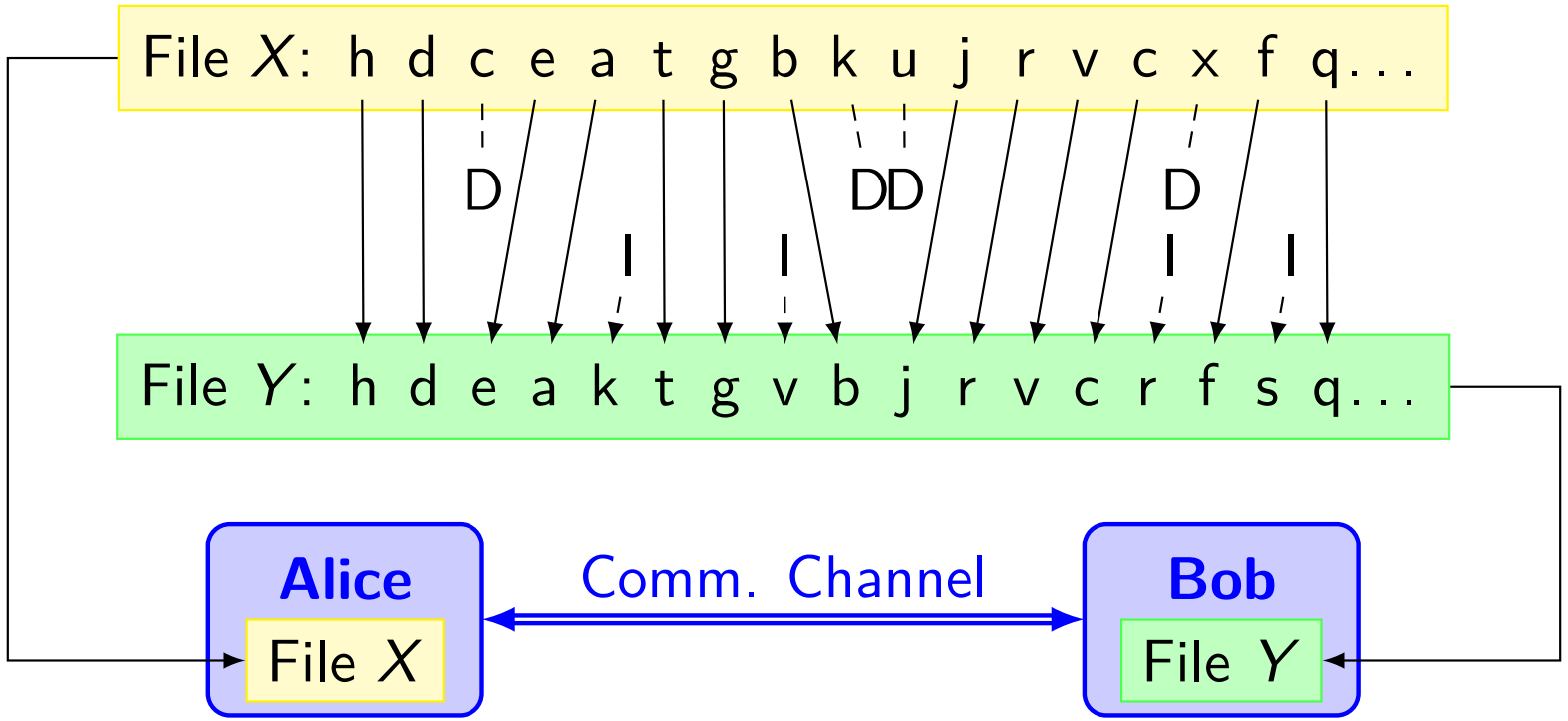

Goal: Interactive Communication Scheme

Allow Bob to recover X from Y:

- with low probability of error,
- with low communication cost.

Prior Related Work

- Scheme that corrects a single edit (non-binary):

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- Our work: scheme for fixed rate of edits:

  
  N. Bitouzé and L. Dolecek, "Synchronization from insertions and deletions under a non-binary, non-uniform source", 2013.

  
  S. M. S. Tabatabaei and L. Dolecek, "A deterministic, polynomial-time protocol for synchronizing from deletions", 2013.

Overview of our Synchronization Scheme

Node A

File X: hdcatgbkujinntuqjrvxfqxrzleydwajgndtwanyohdcyhzrnrm

File Y: hdcatbkujintkuqjrvxqxrledwrajgnidtwayohdcyhzrnrm

Node B

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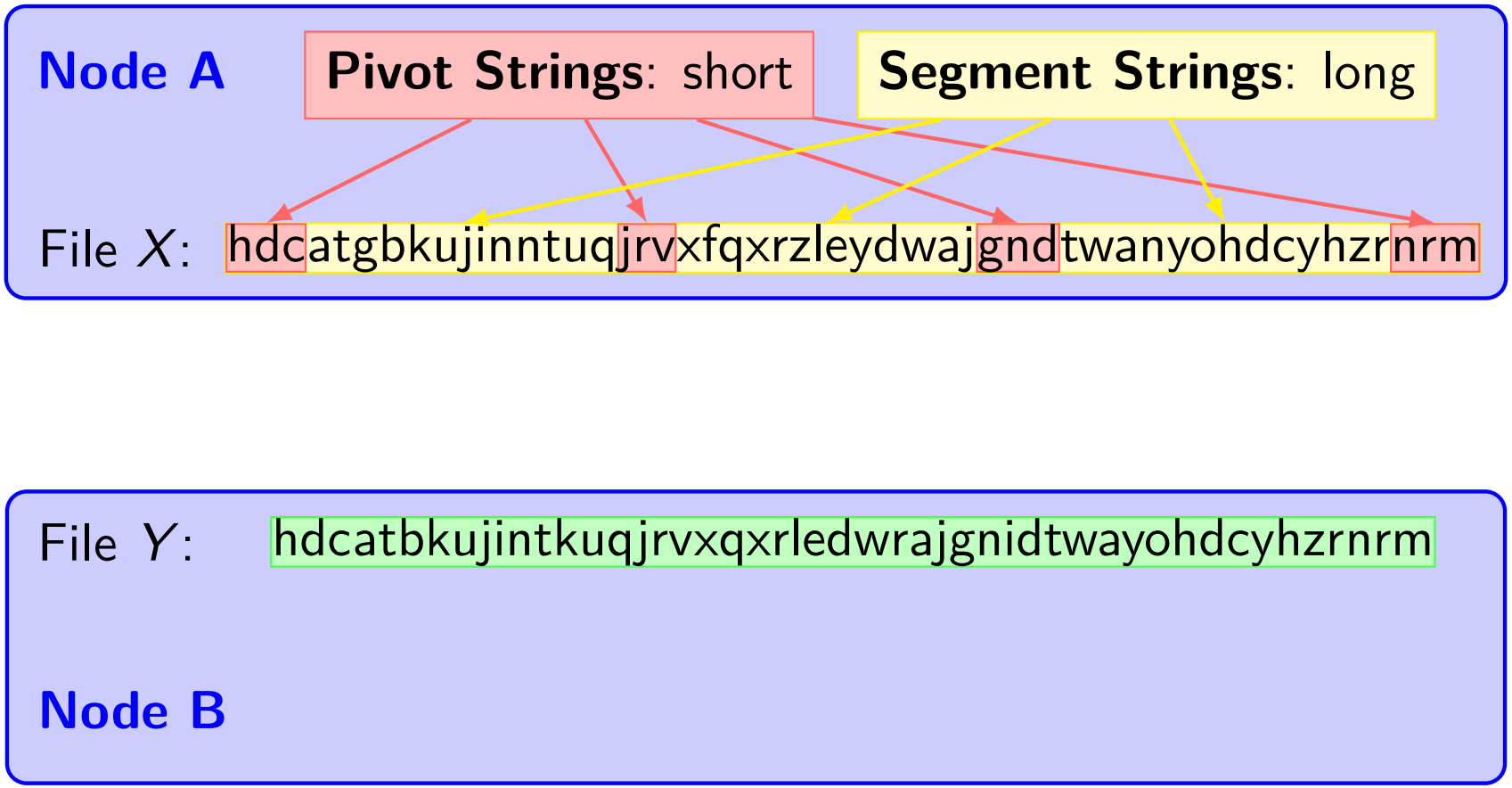

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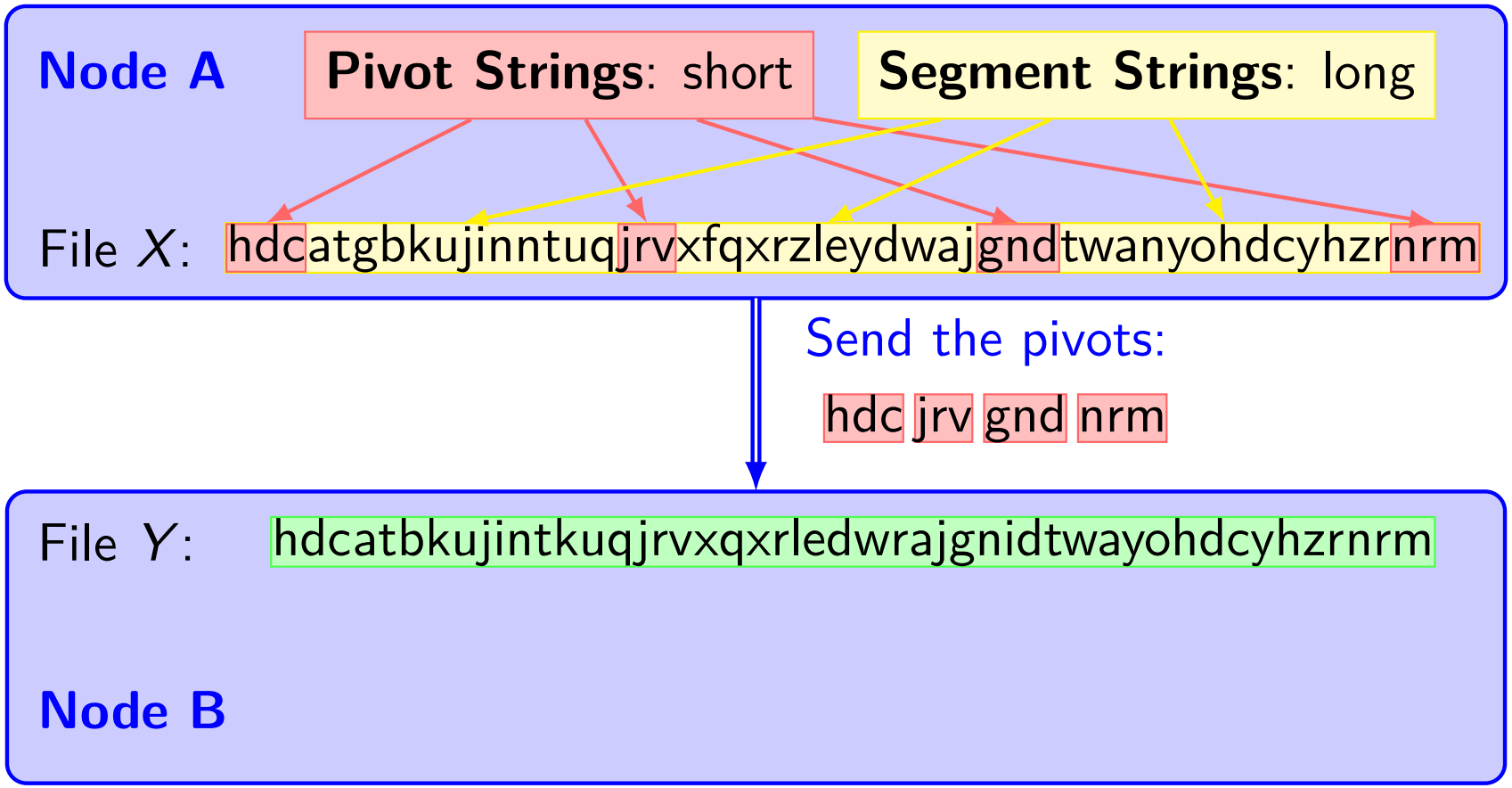

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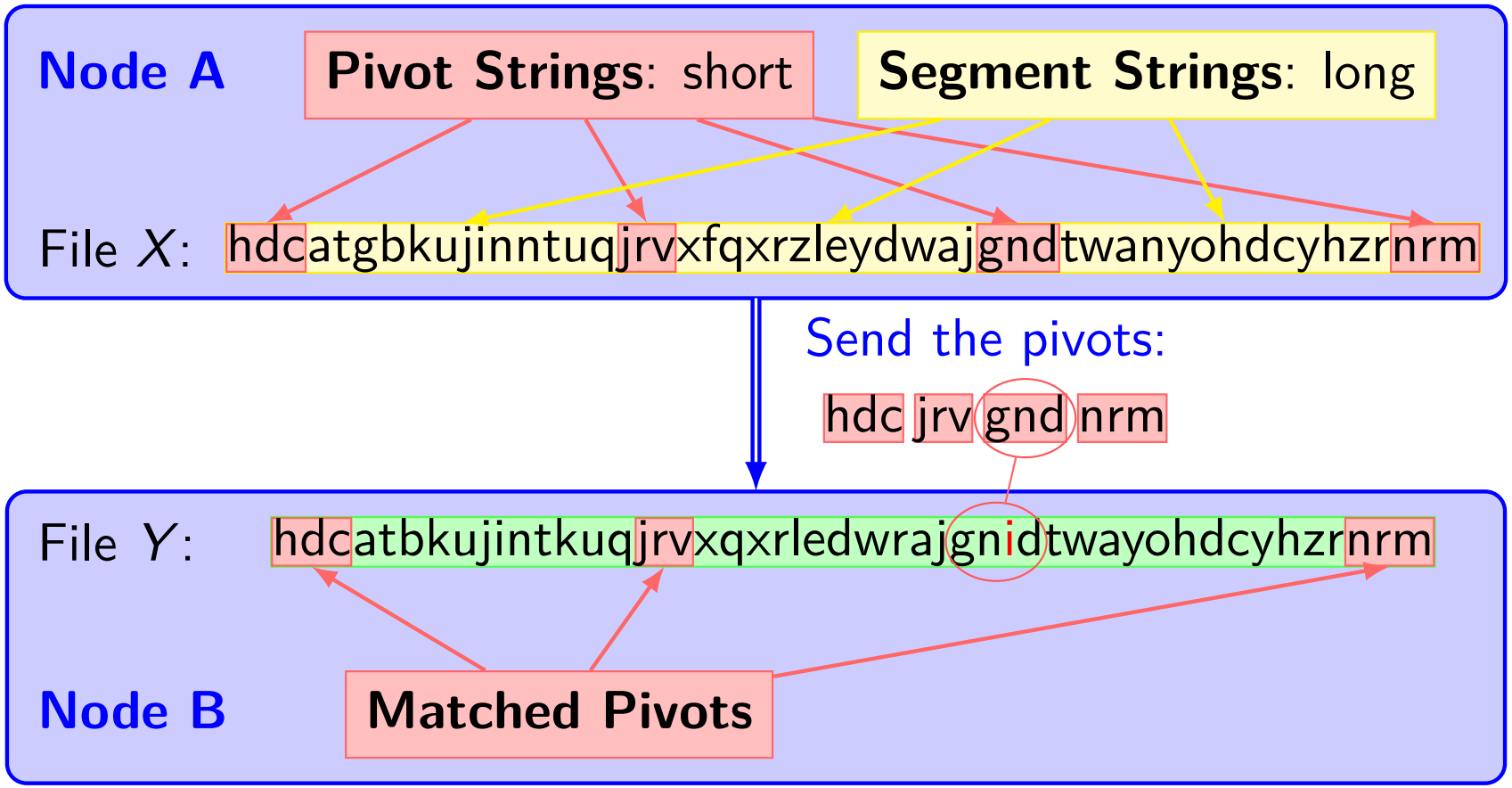

1. Matching Module: Matches the pivot strings.

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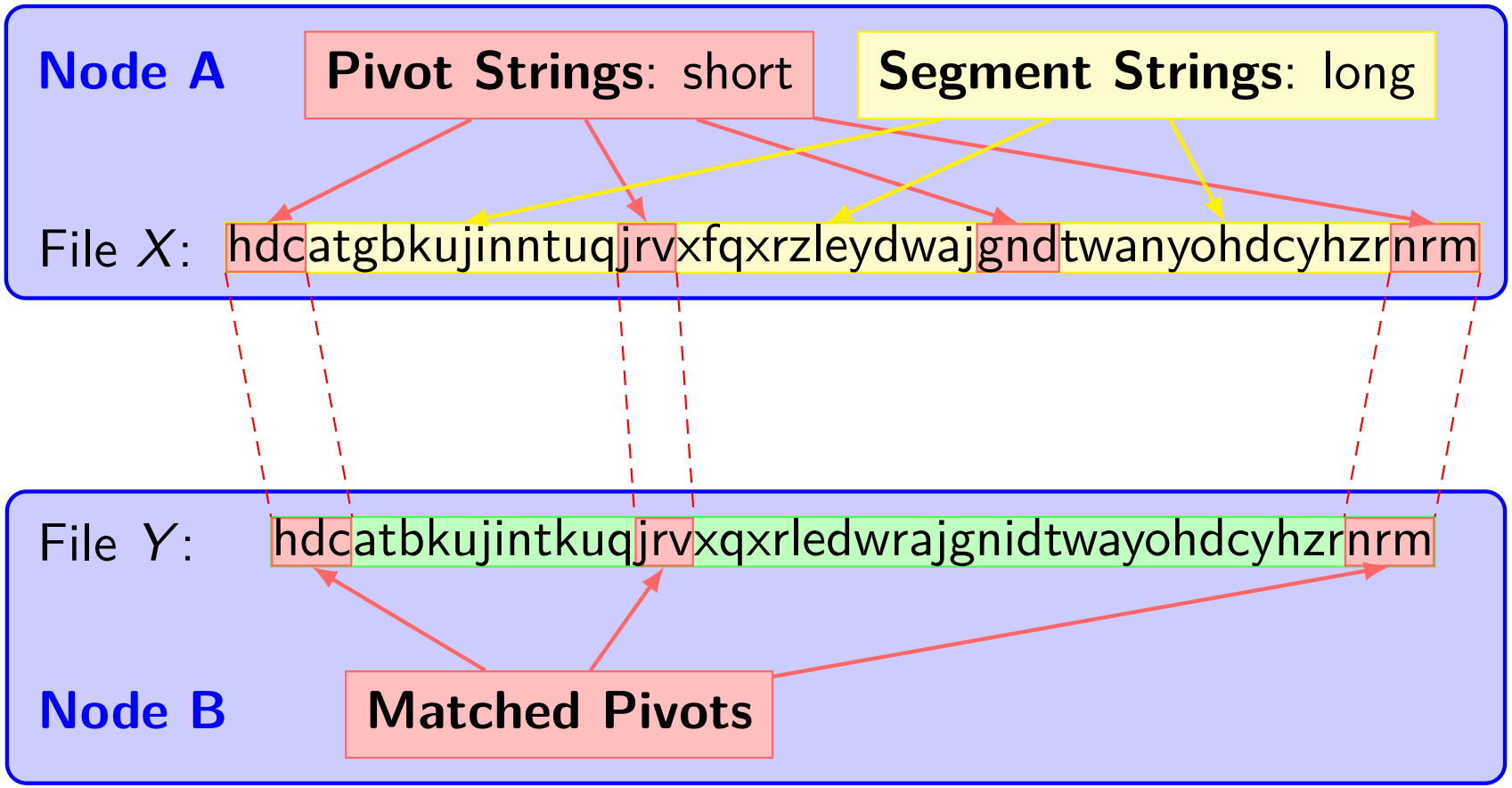

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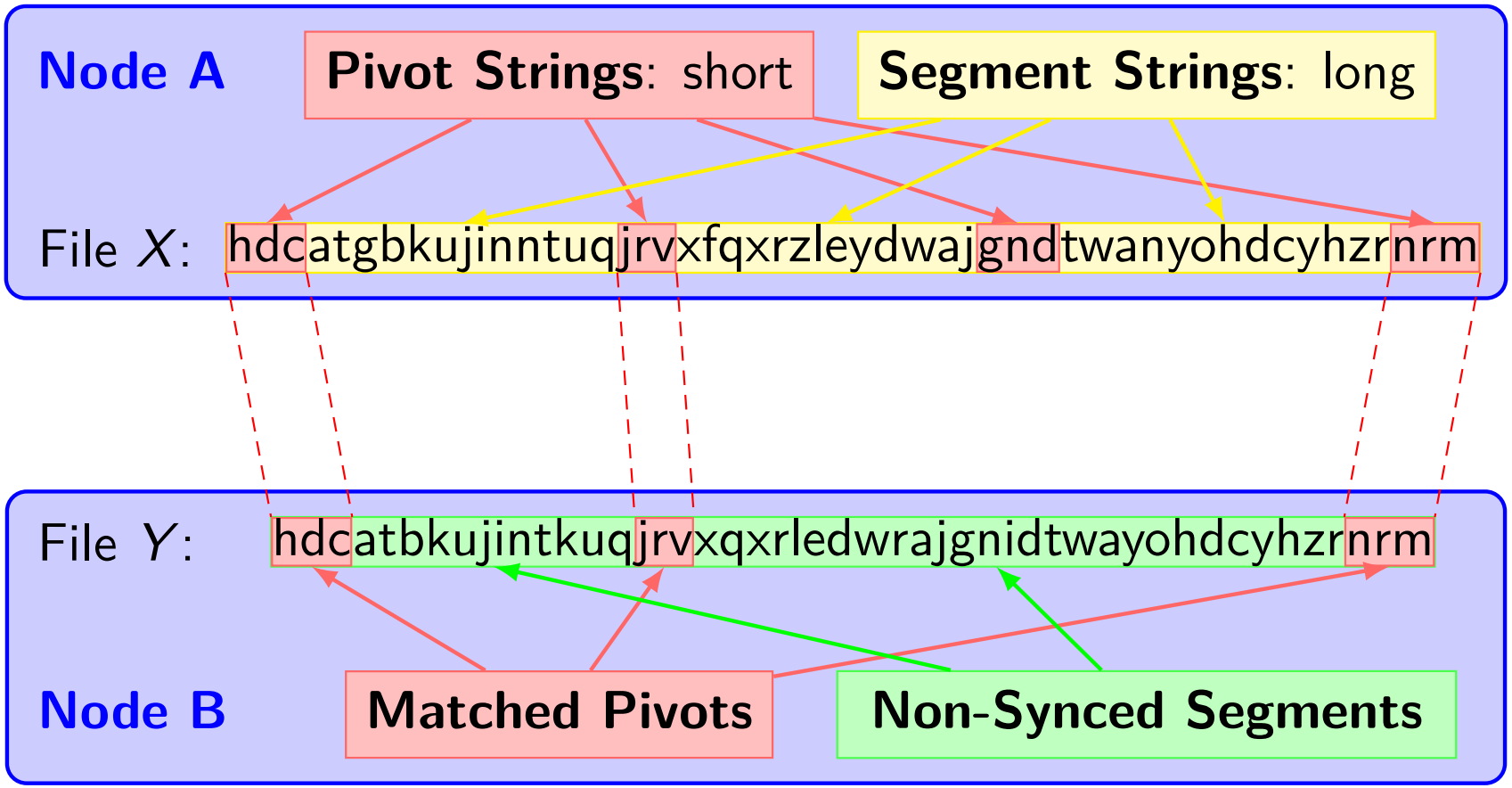

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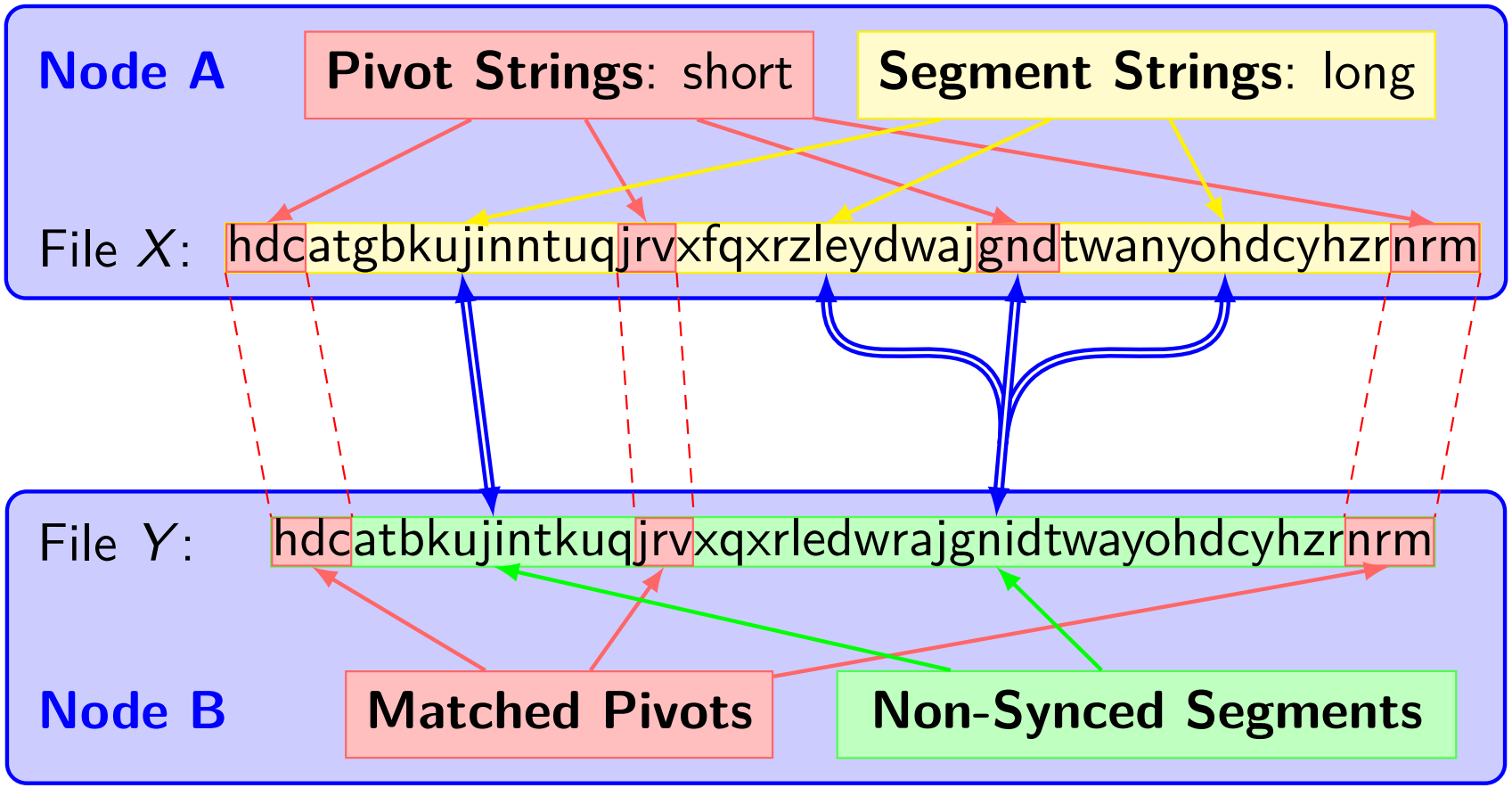

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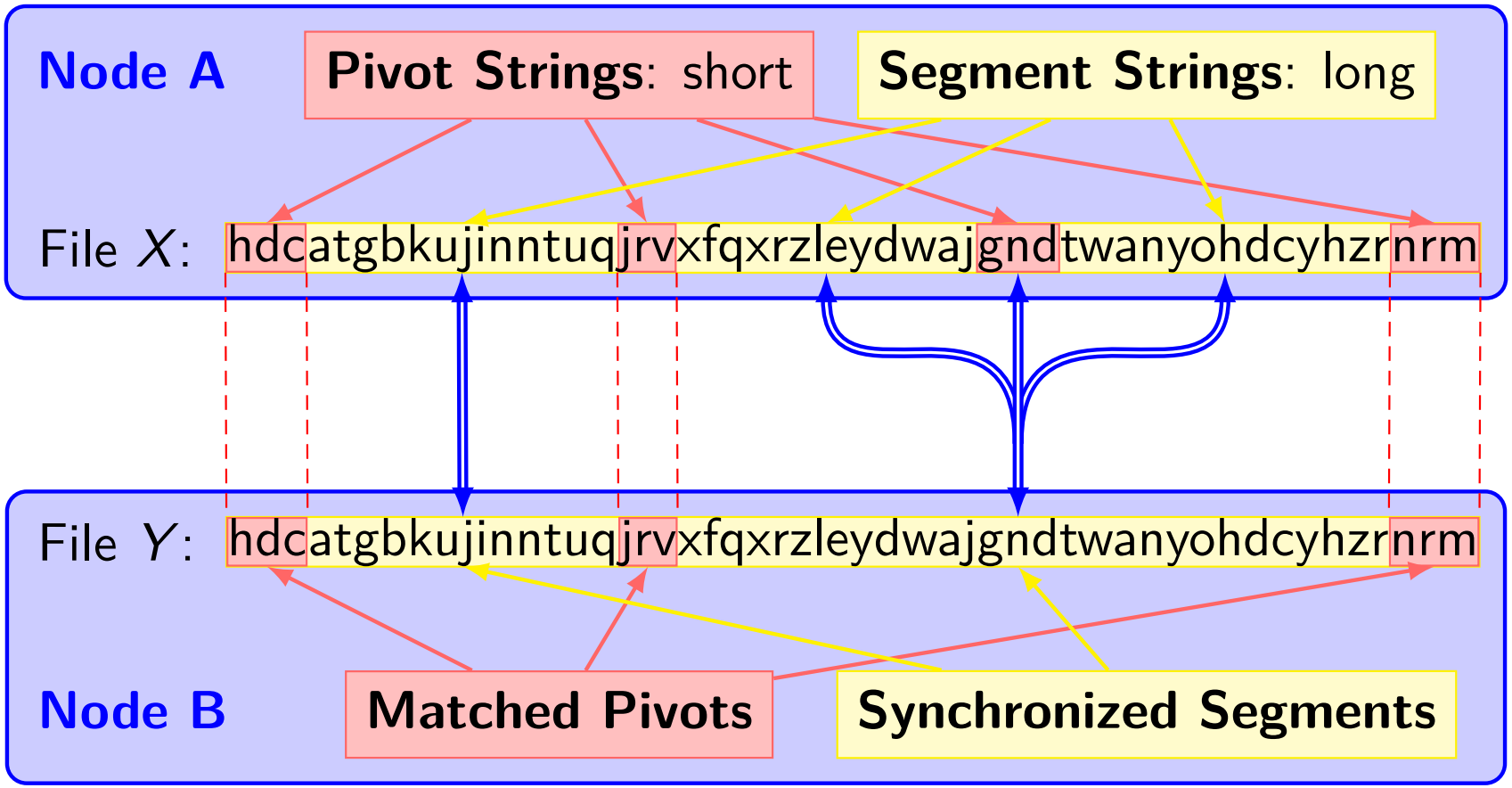

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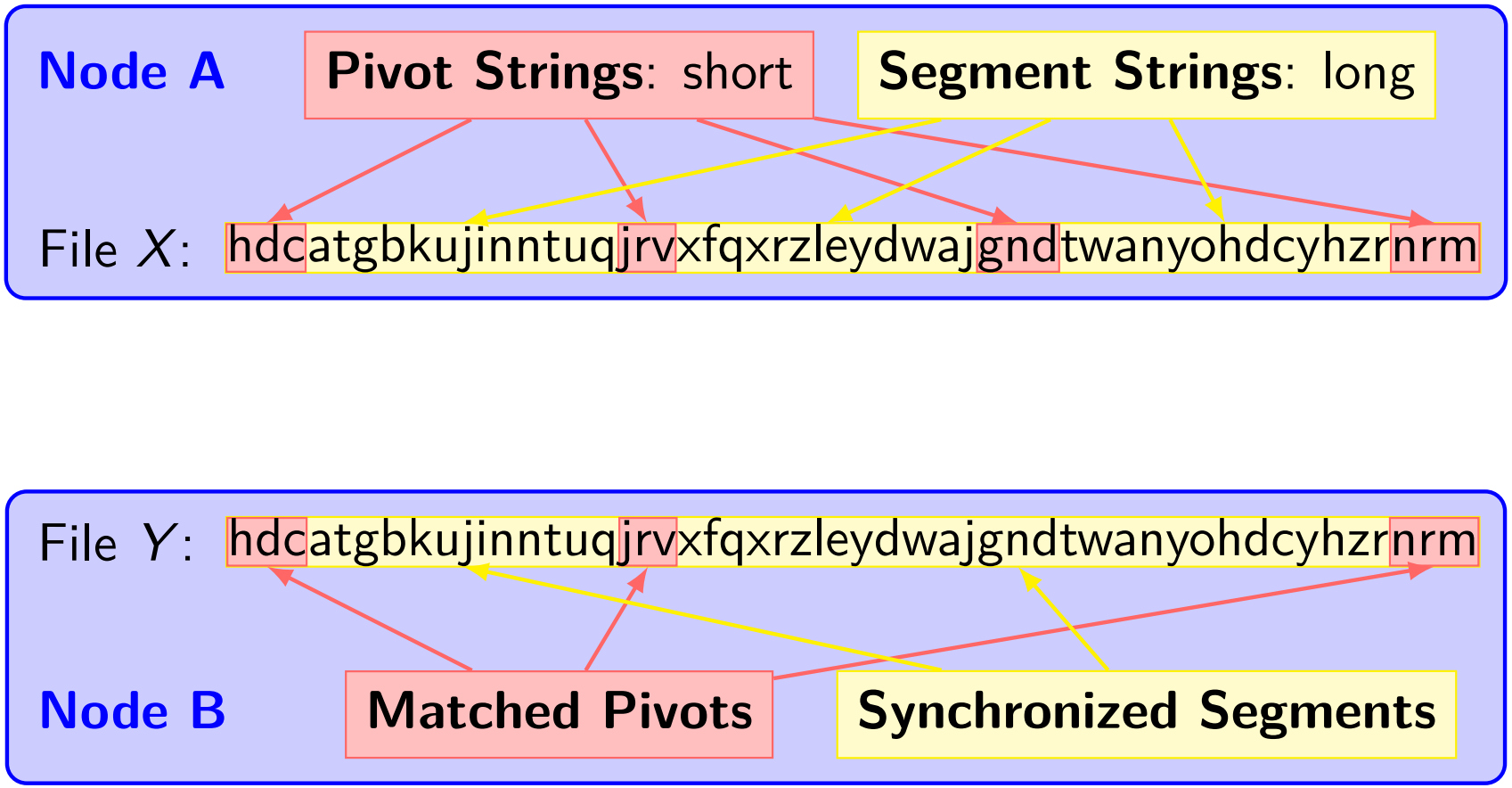

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3. Channel Coding Module: Recovers from residual errors if any.

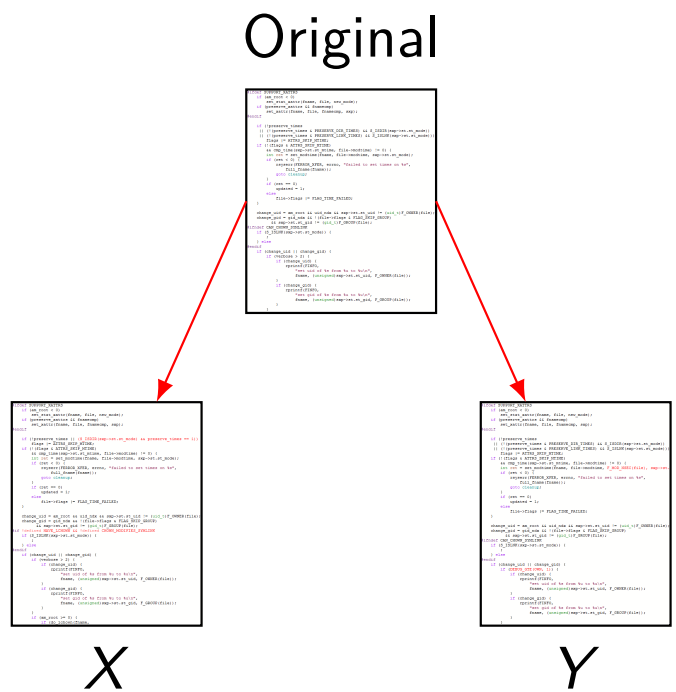
Main Result

Considering the scenario where

- File Y is an edited version of file X,
- Alice has file X,
- Bob has file Y,
- Alice $\overset{\text{Comm. Channel}}{\longleftrightarrow}$ Bob,

we provide a synchronization scheme with

- little communication required (within a constant factor of optimal rate),
- negligible error probability.



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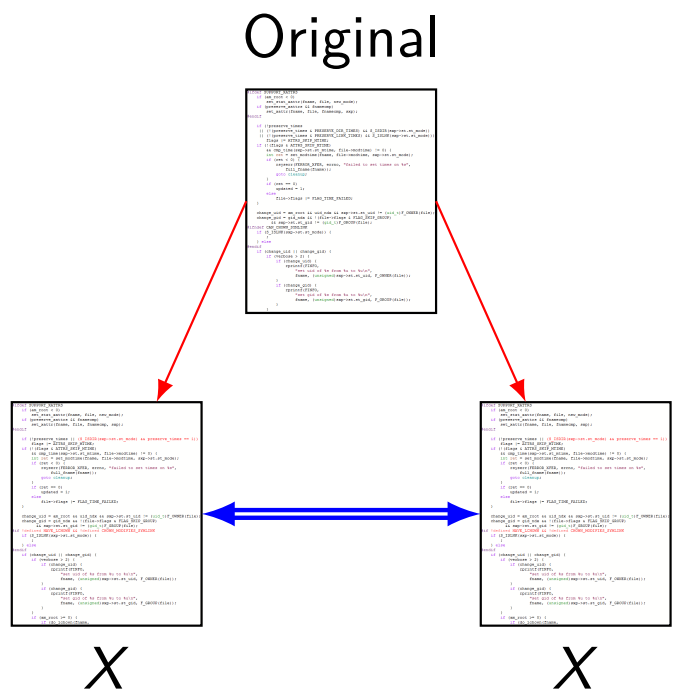
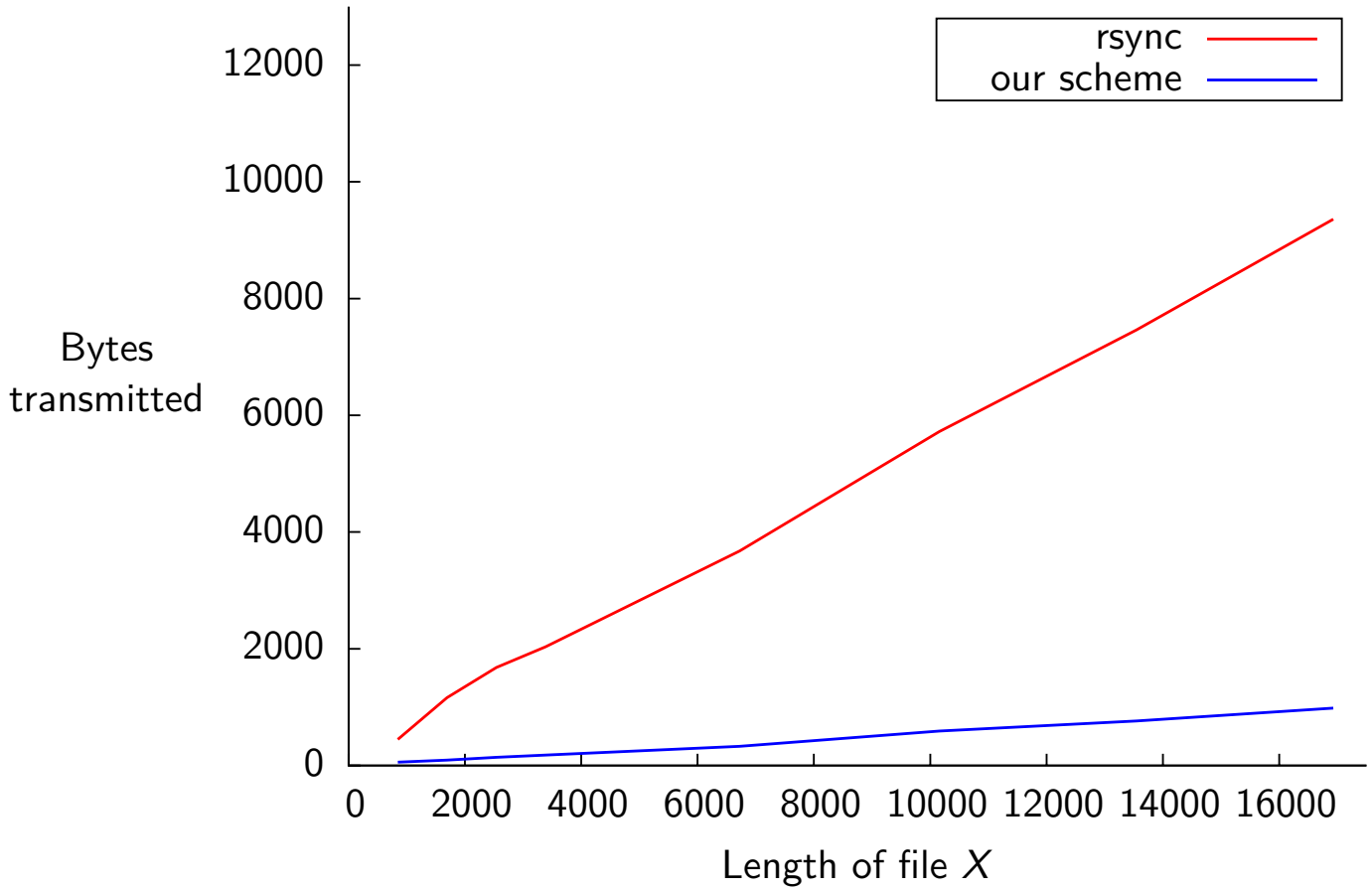


Comparison with rsync

- $\beta = 0.01$, i.i.d. file, i.i.d. edits,
- rsync block-size optimized,
- Our pivot length: 5, segment length: 100.



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  (e.g., if the files are source code, exploit that structure),
- Optimize the implementation
  (in terms of both computation and network usage).