The `open-cbgm` Library: Design and Demonstration

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Note: A crash-course document on the CBGM is available at https://vt.academia.edu/JoeyMcCollum.

Customizable, Standard-compliant Input

```
<listWit>
    <witness xml:id="A" />
    <witness xml:id="B" />
</listWit>
```

```
<app n="B00K0V0U0">
    <rdg n="a" wit="#A">ειπεν</rdg>
    <rdg n="b" wit="#B">ελεγεν</rdg>
    <note>
        <fs>
            <f name="connectivity">
                <numeric value="5" />
            </f>
        </fs>
        <graph type="directed">
            <node n="a" />
            <node n="b" />
            <arc from="a" to="b" />
        </graph>
    </note>
</app>
```

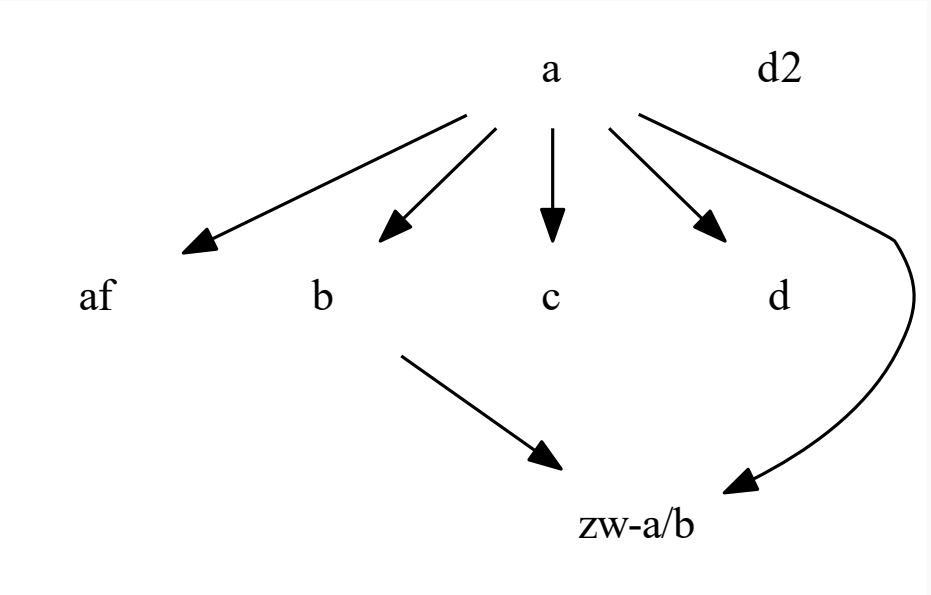
- Database is populated from a collation file in TEI XML format
- With a SQLite database, the entire process can be done locally

XML	Object	DB Table
`witness`	Witness	`WITNESSES`
`app`	Variant passage	`VARIATION_UNITS`
`rdg`	Variant reading	`READINGS`
`graph`	Local stemma	`READING_RELATIONS`

Local Stemmata

```
<graph type="directed">
    <node n="a" />
    <node n="af" />
    <node n="b" />
    <node n="c" />
    <node n="d" />
    <node n="d2" />
    <node n="zw-a/b" />
    <arc from="a" to="af" />
    <arc from="a" to="b" />
    <arc from="a" to="c" />
    <arc from="a" to="d" />
    <arc from="a" to="zw-a/b" />
    <arc from="b" to="zw-a/b" />
</graph>
```

- Local stemmata are fully customizable in the XML input



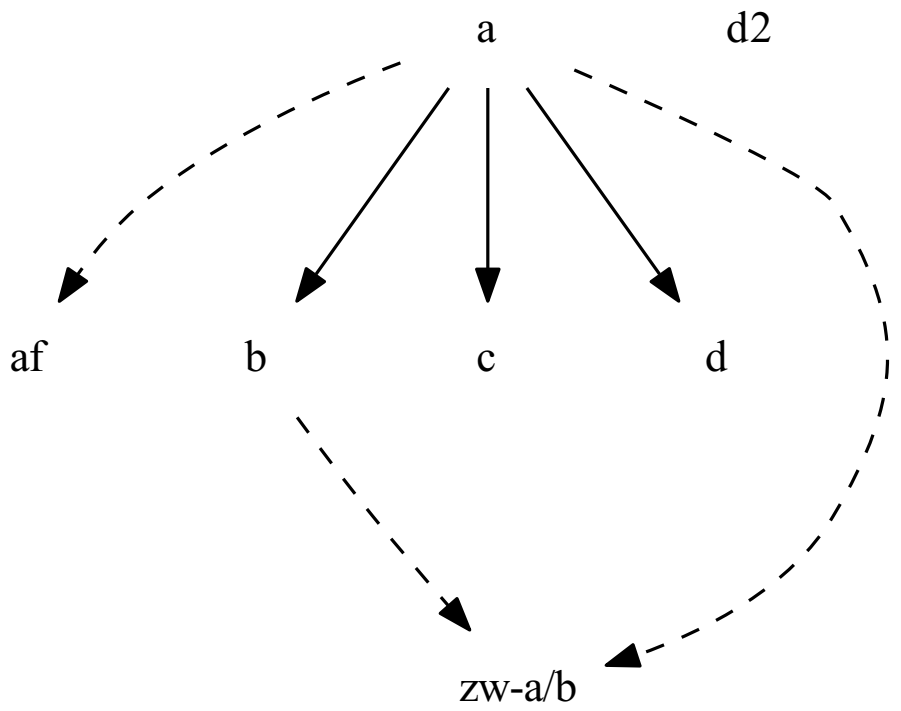
Local Stemmata

- Reading types can be collapsed

`-z defective -z ambiguous`

3Jo 1:4/22-26

a: εν αληθεια περιπατουντα
af: εν αληθεια περιπατουντο
b: εν τη αληθεια περιπατουντα
c: περιπατουντα εν αληθεια
d: τη αληθεια περιπατουντα
zw-a/b: εν [13-15]τουντα



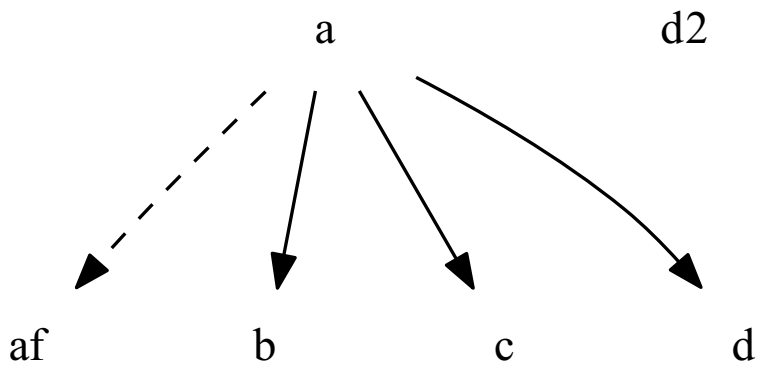
Local Stemmata

- Reading types can be dropped

`-z defective -Z ambiguous`

3Jo 1:4/22-26

a: εν αληθεια περιπατουντα
af: εν αληθεια περιπατουντο
b: εν τη αληθεια περιπατουντα
c: περιπατουντα εν αληθεια
d: τη αληθεια περιπατουντα



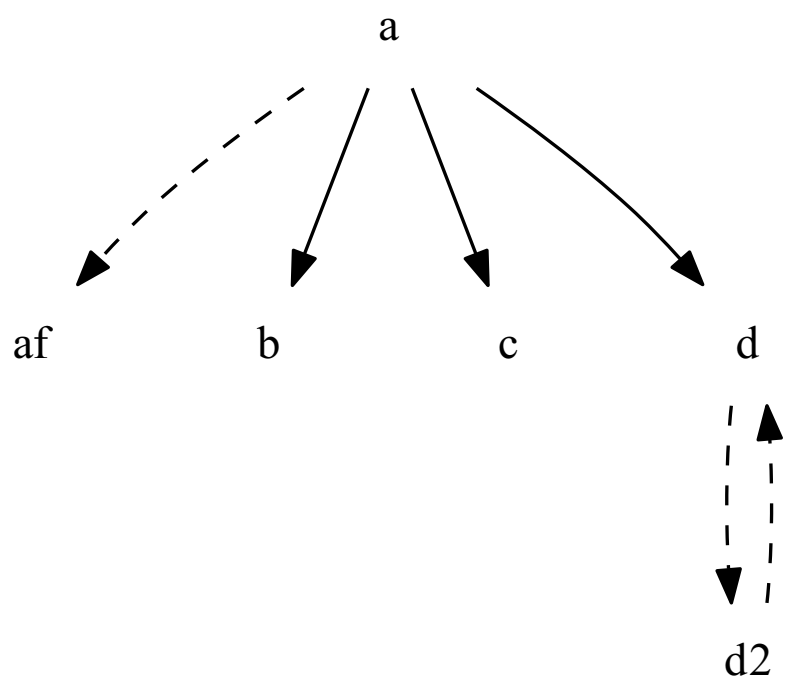
Local Stemmata

- Split attestations can be merged

```
-z defective -Z ambiguous --merge-splits
```

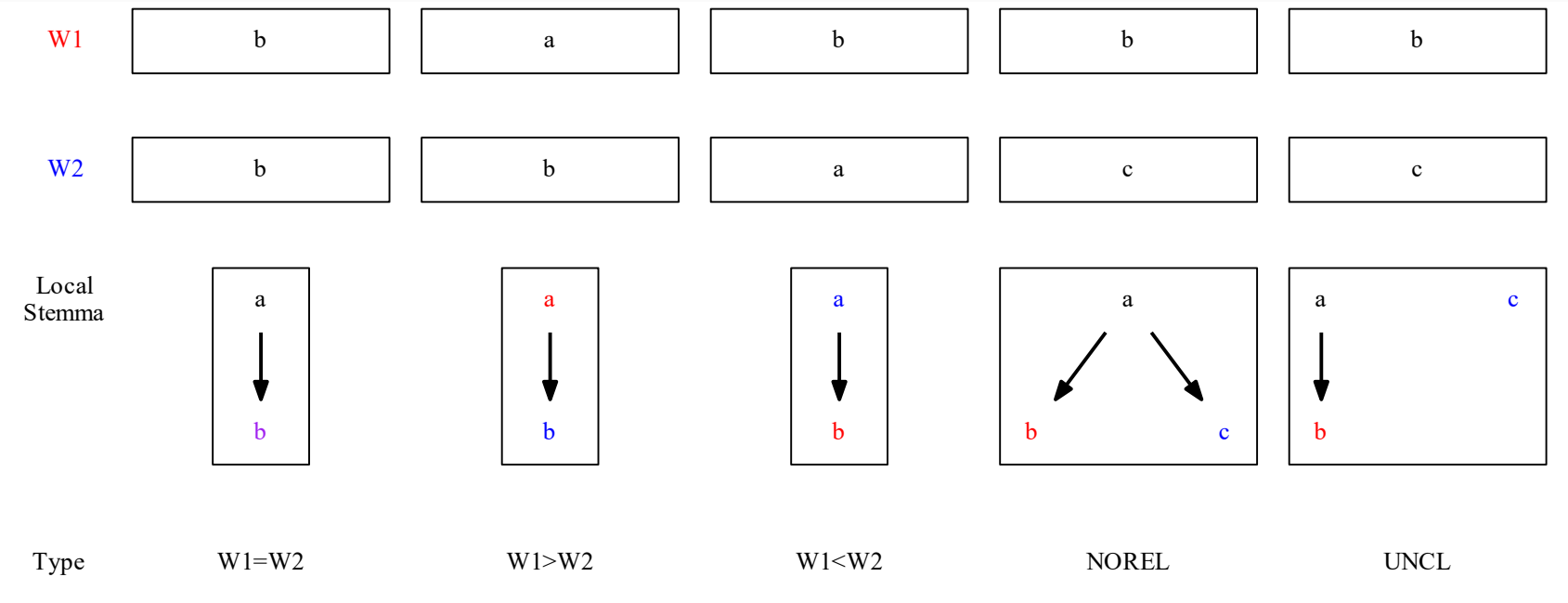
3Jo 1:4/22-26

a: εν αληθεια περιπατουντα
af: εν αληθεια περιπατουντο
b: εν τη αληθεια περιπατουντα
c: περιπατουντα εν αληθεια
d: τη αληθεια περιπατουντα



Genealogical Relationships

- The `open-cbgm` library encodes genealogical relationships relative to a given witness as bitmaps (one bit per passage)

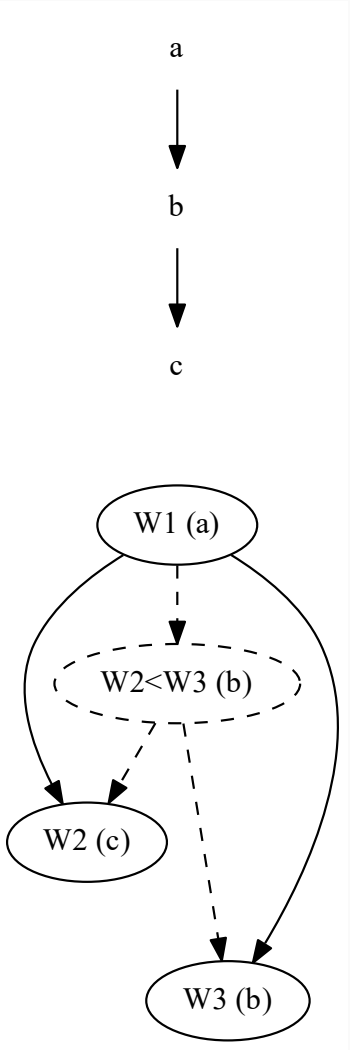


$$\texttt{agree} = [1,0,0,0,0]^\star \qquad \texttt{norel} = [0,0,0,1,0]$$

$$\texttt{prior} = [0,1,0,0,0] \qquad \texttt{uncl} = [0,0,0,0,1]$$

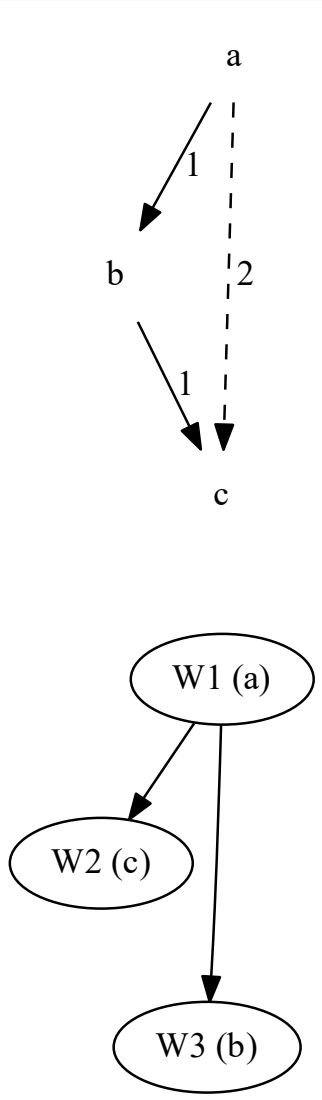
$$\texttt{posterior} = [0,0,1,0,0] \qquad \texttt{expl} = [1,0,1,0,0]^\star$$

Criteria for Explained Readings



- In the local stemma to the left, does *a* explain *c*?
- The “classic” rules of the CBGM as implemented by CCeH and Edmondson say *no*: the explaining reading must agree with or be directly prior to the explained reading
- Intermediary nodes may be needed to connect the global stemma

Criteria for Explained Readings

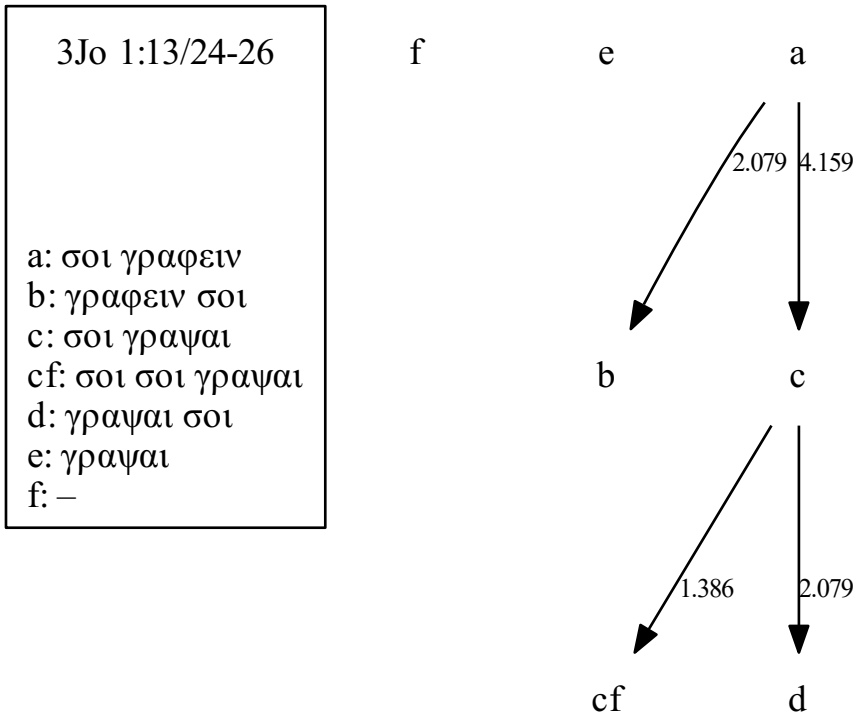


- The `open-cbgm` implementation relaxes this criterion: any reading with a path in the local stemma to the reading in question explains it
- No intermediary nodes needed (but multiple changes in the same passage may be implied along the edges)

Genealogical Relationship Costs

```
<graph type="directed">
    <node n="a" />
    <node n="b" />
    <node n="c" />
    <node n="cf" />
    <node n="d" />
    <node n="e" />
    <node n="f" />
    <arc from="a" to="b">
        <label>2.079</label>
    </arc>
    <arc from="a" to="c">
        <label>4.159</label>
    </arc>
    <arc from="c" to="cf">
        <label>1.386</label>
    </arc>
    <arc from="c" to="d">
        <label>2.079</label>
    </arc>
</graph>
```

- In `open-cbgm`, cost = shortest path length
- Edge weights in `label` element
- Example: scribal change log-likelihood $w = -\log p$

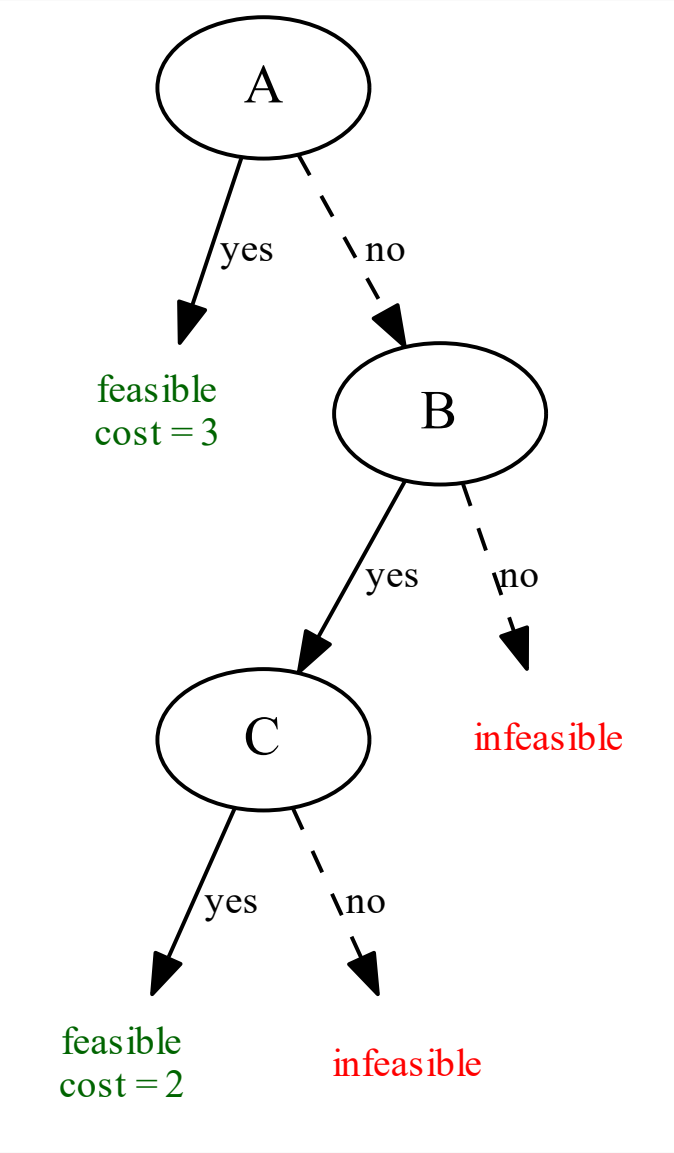


Substemma Optimization

Ancestor	Explained	Cost
A	$[1, 1, 1, 1]$	3
B	$[1, 1, 0, 0]$	1
C	$[0, 1, 1, 1]$	1

- Substemma optimization can be cast as a *weighted set cover* problem
- Example: witness D, extant in four passages, has three potential ancestors A, B, and C
- The substemma {A} is *feasible*, in that it covers all of D's passages (i.e., explains D's readings at all of them)
- But {B, C} is feasible and *optimal* in terms of total cost (2 rather than 3)

Substemma Optimization



- For a witness with n potential ancestors, evaluating all of its 2^n possible substemmata by brute force would be prohibitive
- The *branch-and-bound* heuristic (pictured left) finds all minimum-cost substemmata quickly in practice
- Easily adpated to find all substemmata within a given cost

CBGM Iterative Workflow

DEMO

Conclusion

- The `open-cbgm` core library is freely available at https://github.com/jjmccollum/open-cbgm, and the standalone command-line utility is available at https://github.com/jjmccollum/open-cbgm-standalone
- A more user-friendly web interface is being co-developed with Tim and Jessie Stoel (Phoenix Seminary)
- Currently being used by David Flood (University of Edinburgh) for his PhD dissertation on GA 0150, 0151, 1506 and 2110

References

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Appendix: Comparison of CBGM Implementations

	INTF/CCeH	Edmondson	`open-cbgm`
Input format	MySQL DB	Python script	TEI XML
Textual flow ancestry constrained by local stemma edges?	No	Yes	No
Lacunose witnesses allowed in textual flow?	Yes (CCeH)	No	Yes

Appendix: Comparison of CBGM Implementations

	INTF/CCeH	Edmondson	`open-cbgm`
Explanation only by same or parent reading?	Yes	Yes	No
Supports weighted input?	No	No	Yes
Genealogical cost function	Disagreement	Disagreement	Shortest path length
Intermediary nodes needed?	Yes	Yes	No