



Role detection in networks

Social differentiation during the
Reformation

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Why do we have professions?

- ▶ **Differentiation** at several points in history
- ▶ Neolithic Revolution, Industrialisation
- ▶ Lesser known: Reformation

- ▶ **Reformation:** overthrew Catholic Church
- ▶ Theologians and lawyers differentiate [2]
- ▶ **Peace of Augsburg:** conflict of religion negotiated by lawyers [3]



Neolithic Revolution



Industrialisation

⌚ The Reformation: a milestone on the road to professions?



The Diet of Augsburg, 1555

Differentiation of communication

- ▶ **However:** not everyone was a theologian or a lawyer
- ▶ **Communication:** affects everyone



Theologian



Lawyer

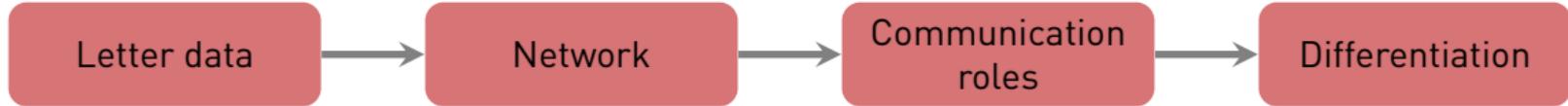


The rest

Research question

How did communication differentiate during the Reformation?

My approach



- ▶ **Communication roles:** *Context-specific patterns* of communication, e.g., mediating, censoring
 - ▶ **Differentiation:** People fulfill *fewer roles* over time
i.e., they become more specialised in their communication
- ⌚ **Spoiler:** Analysis reveals that people become more differentiated in their communication roles

Data and Network

- ▶ 9 letter editions

Luther, Melanchthon, Karlstadt, Bucer, Zwingli,
Bullinger, Vadian, Myconius, Oekolampad

- ▶ 26,663 letters
- ▶ 3.348 reformers
- ▶ time period: 1500–1564
- ▶ nodes: reformers
- ▶ edges: letters
- ▶ directed (sender vs receiver)
- ▶ multiedge (> 1 letter between 2 reformers)



Luther



Melanchthon



Karlstadt



Bucer



Zwingli



Bullinger



Vadian

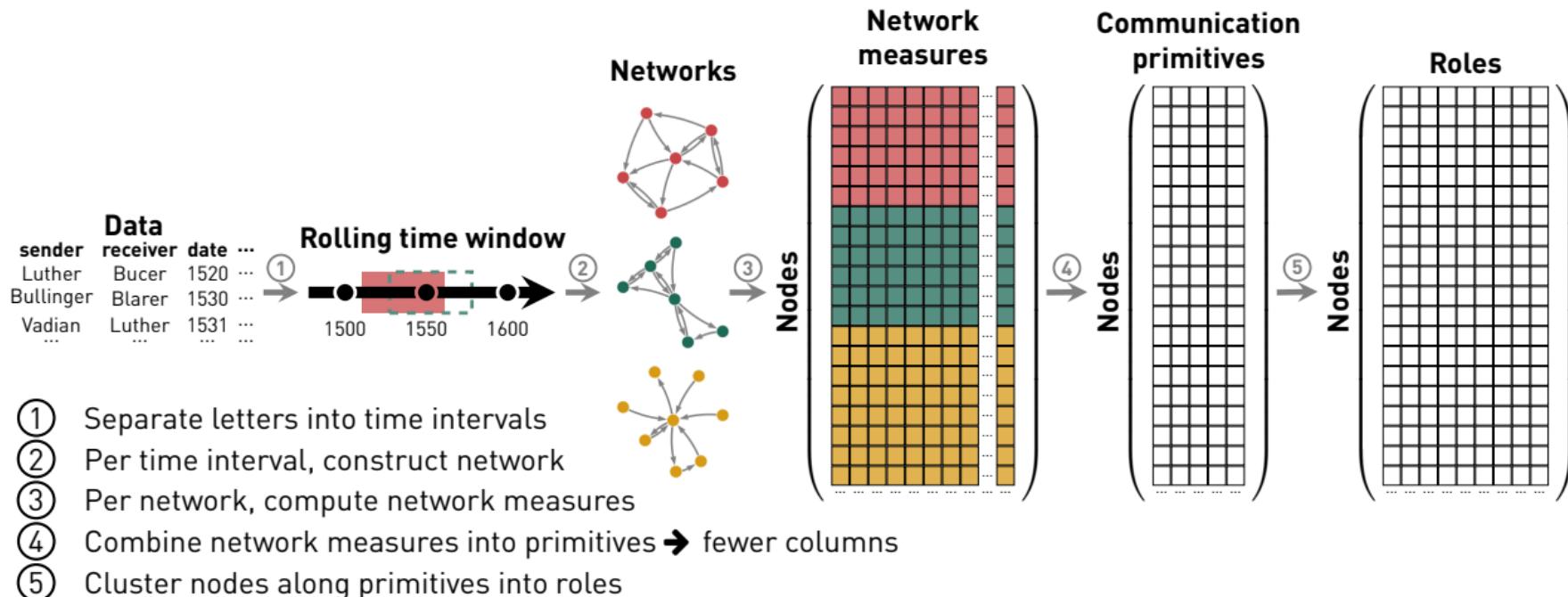


Myconius



Oekolampad

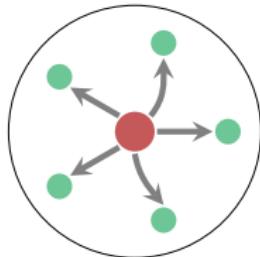
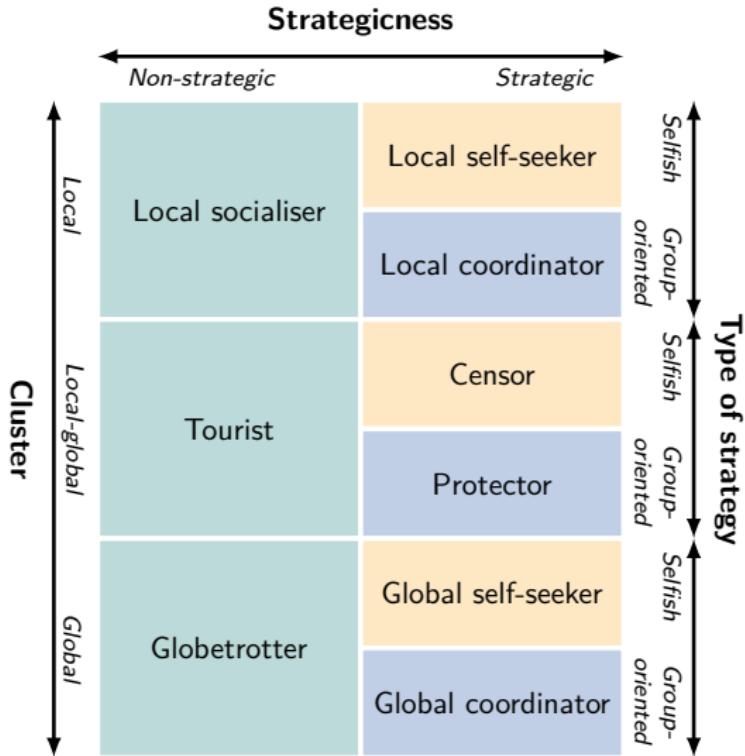
How to compute communication roles?



⌚ Communication roles: nodes with same structural properties in communication network

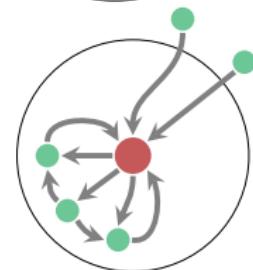
Which roles to look for?

- Theory of communication roles in networks [1]



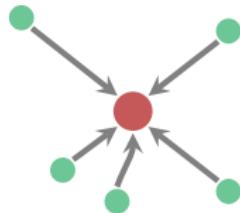
Local socialiser

Contacts others for the sake of fun in her own community.



Protector

Passes external information on to her own community, helps others to connect.



Global self-seeker

Gathers information from the whole network for her own use.

What do the role results look like?

Membership probability per role

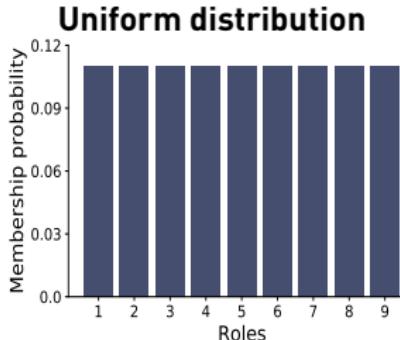
| | | Membership probability per role | | | | | | | | | |
|----------|-------------------|---------------------------------|---------|--------------|-------------------|-----------|--------------------|------------------|--------|--------------------|--|
| | | Local socialiser | Tourist | Globetrotter | Local coordinator | Protector | Global coordinator | Local socialiser | Censor | Global self-seeker | |
| Reformer | per time interval | 0.11 | 0.11 | 0.11 | 0.11 | 0.13 | 0.11 | 0.11 | 0.11 | 0.11 | |
| Luther | 1500 – 09 | 0.11 | 0.11 | 0.11 | 0.11 | 0.13 | 0.11 | 0.11 | 0.11 | 0.11 | |
| Bucer | 1500 – 09 | 0.02 | 0.07 | 0.63 | 0.01 | 0.04 | 0.10 | 0.01 | 0.07 | 0.04 | |
| Zwingli | 1500 – 09 | 0.09 | 0.13 | 0.17 | 0.02 | 0.09 | 0.12 | 0.06 | 0.15 | 0.17 | |
| ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | |
| Luther | 1520 – 29 | 0.44 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.09 | 0.07 | 0.07 | |
| Bucer | 1520 – 29 | 0.13 | 0.26 | 0.32 | 0.04 | 0.01 | 0.15 | 0.02 | 0.04 | 0.04 | |
| Zwingli | 1520 – 29 | 0.17 | 0.16 | 0.08 | 0.04 | 0.18 | 0.13 | 0.07 | 0.08 | 0.08 | |
| ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | |

- For each reformers and time interval compute membership probability per role

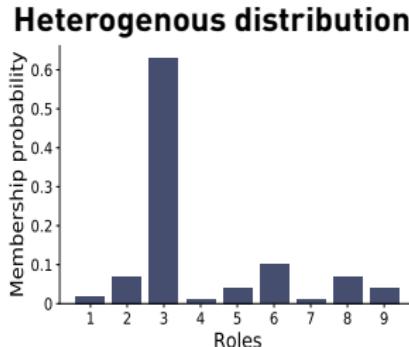
How to measure differentiation?

Reformer per time interval

| | | Membership probability per role | | | | | | | | |
|---------|-----------|---------------------------------|------|------|------|------|------|------|------|------|
| Luther | 1500 – 09 | 0.11 | 0.11 | 0.11 | 0.11 | 0.13 | 0.11 | 0.11 | 0.11 | 0.11 |
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| ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... |
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| ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... |



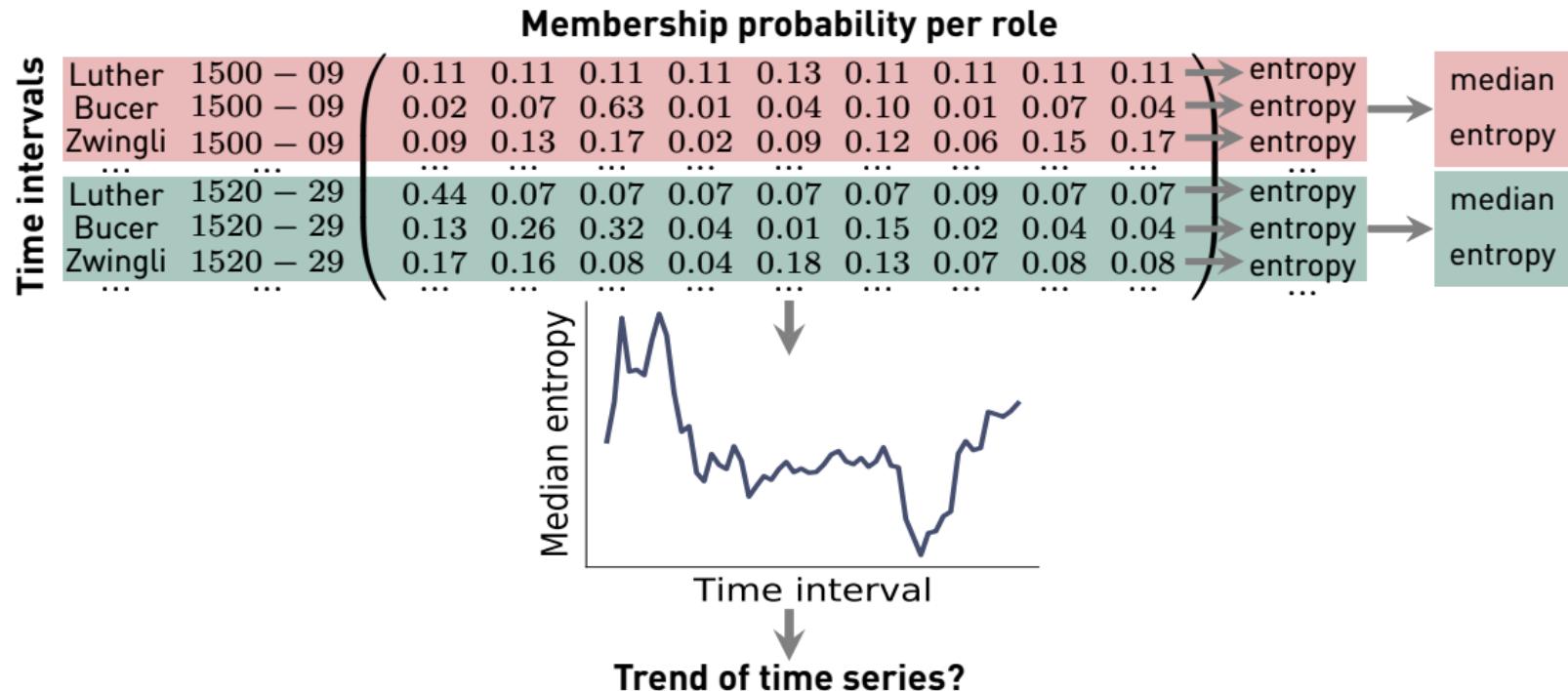
- ⌚ Equal probabilities across roles
- ⌚ Large entropy



- ⌚ Unequal probabilities across roles
- ⌚ Small entropy

- ⌚ Entropy measures heterogeneity of a probability distribution
- ⌚ Apply entropy to distribution of role membership probabilities
- ⌚ Heterogeneous = specialised: small entropy

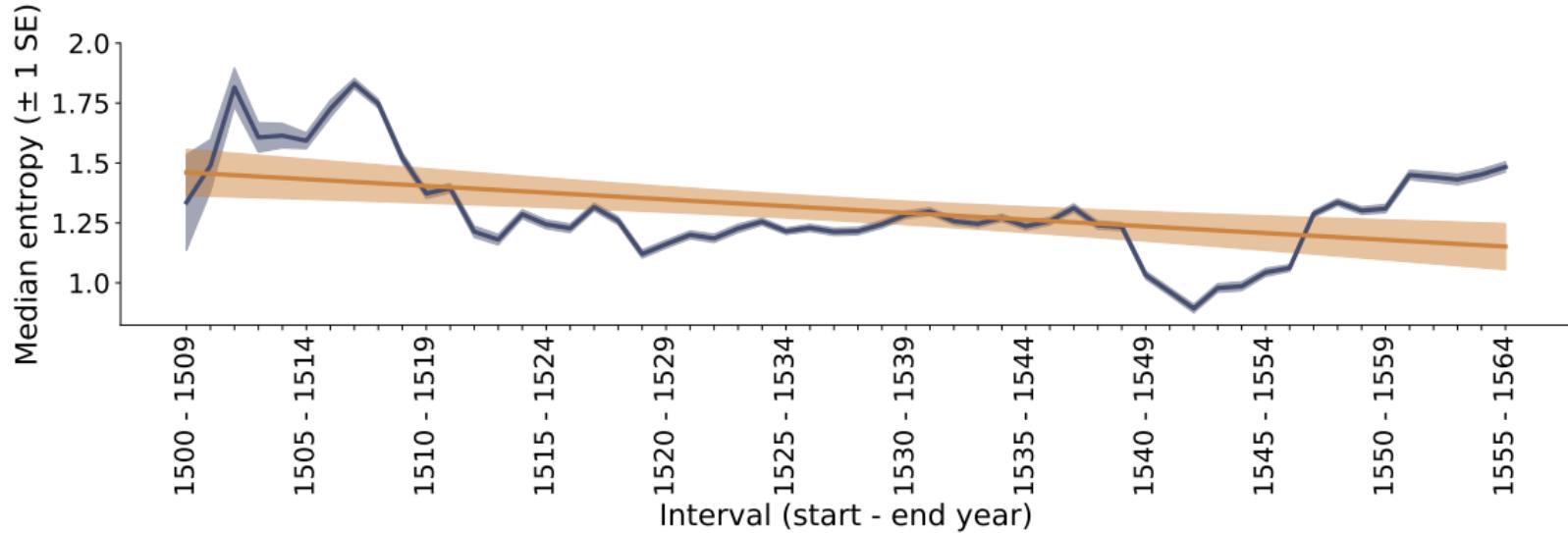
How to measure differentiation over time?



- ⌚ Differentiation: median entropy has to decrease over time

Trend of entropy time series: simple model

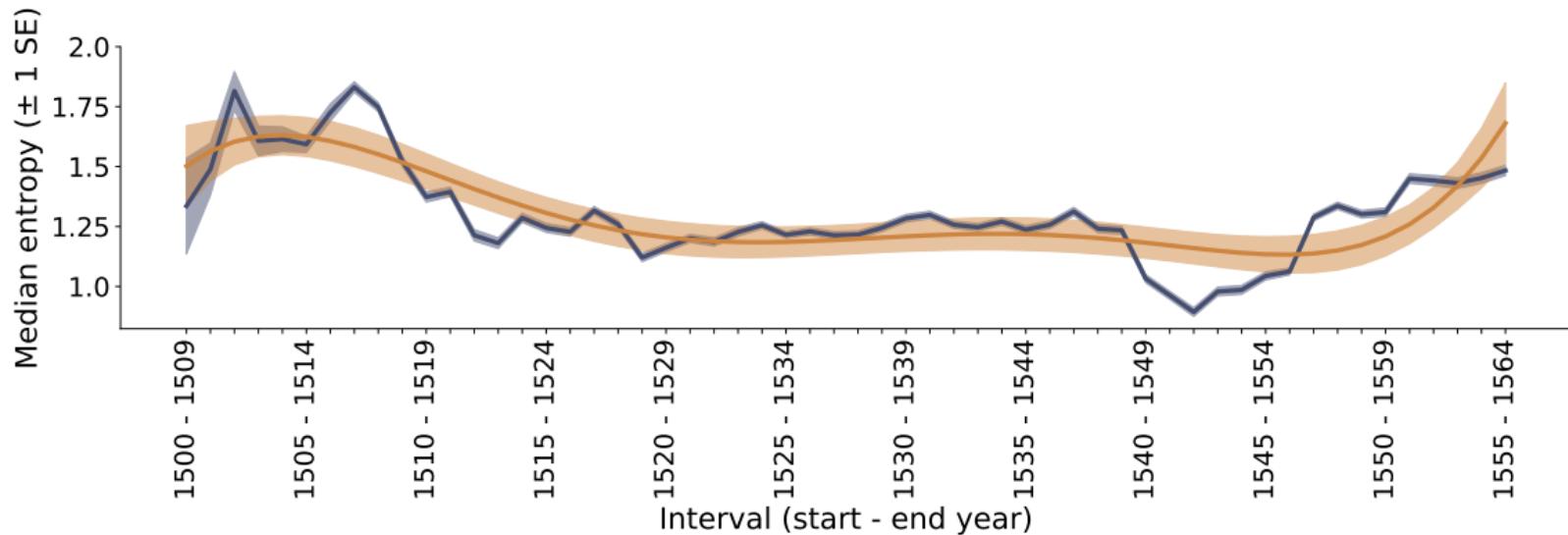
- **Fitted model:** Linear regression, $x = \text{time interval}$, β_1 : general trend
- median entropy = $\beta_0 + \beta_1 x$



⌚ $\beta_1 = -0.006 \rightarrow \text{negative trend}$

Trend of entropy time series: complex model

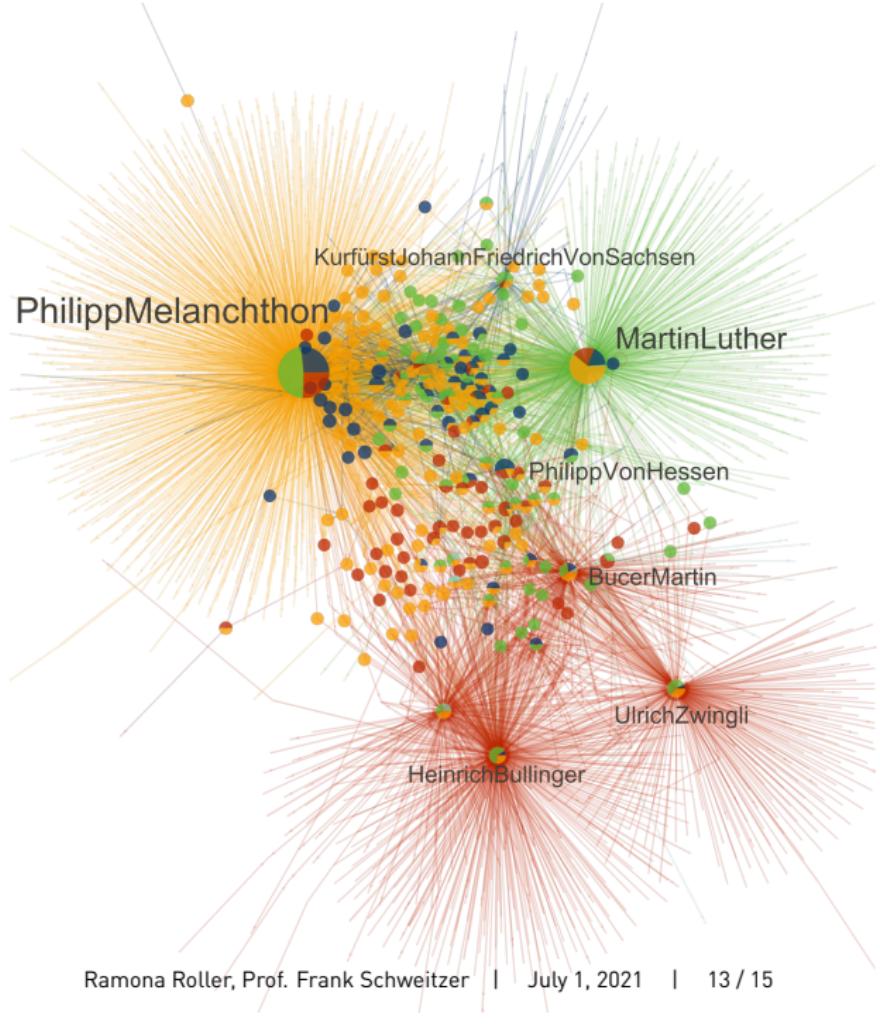
- **Fitted model:** 5th degree polynomial, $x = \text{time interval}$, β_1 : general trend
- median entropy = $\beta_0 + \beta_1 x + \beta_2 x^2 + \beta_3 x^3 + \beta_4 x^4 + \beta_5 x^5$



- ⌚ $\beta_1 = -0.68 \rightarrow \text{negative trend}$
- ⌚ **Reformers become more differentiated in their communication roles**

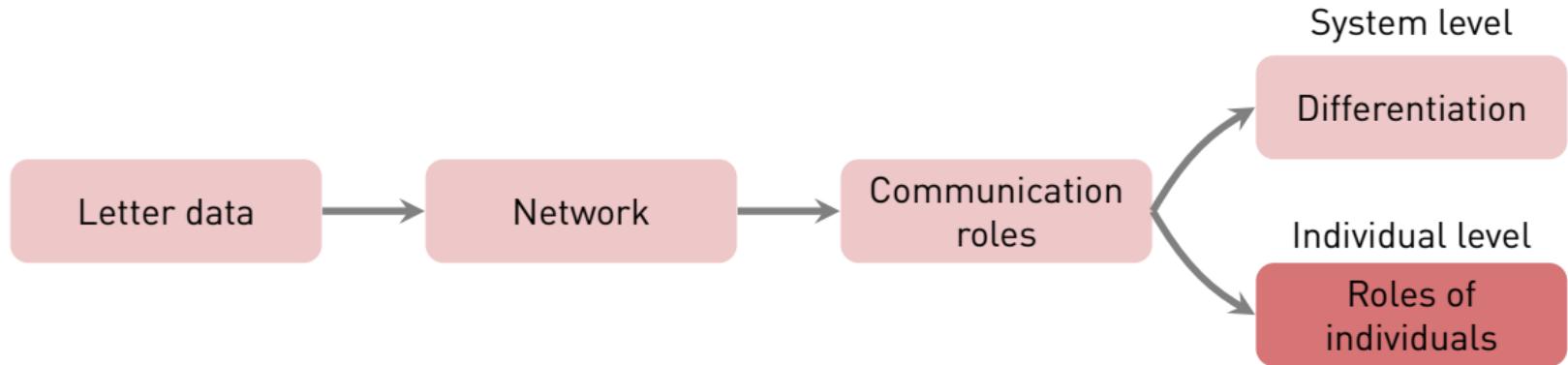
Summary

- ▶ **Differentiation during the Reformation**
 - ▶ Theologians vs lawyers
 - ▶ Laypeople: study communication roles
- ▶ **Measuring differentiation**
 - ▶ **Communication roles** manifest in network structure
 - ▶ Role memberships as probability distribution
 - ▶ **Small entropy** indicates that reformers become specialised in their roles
 - ▶ **Negative trend** of entropy time series indicates **differentiation**



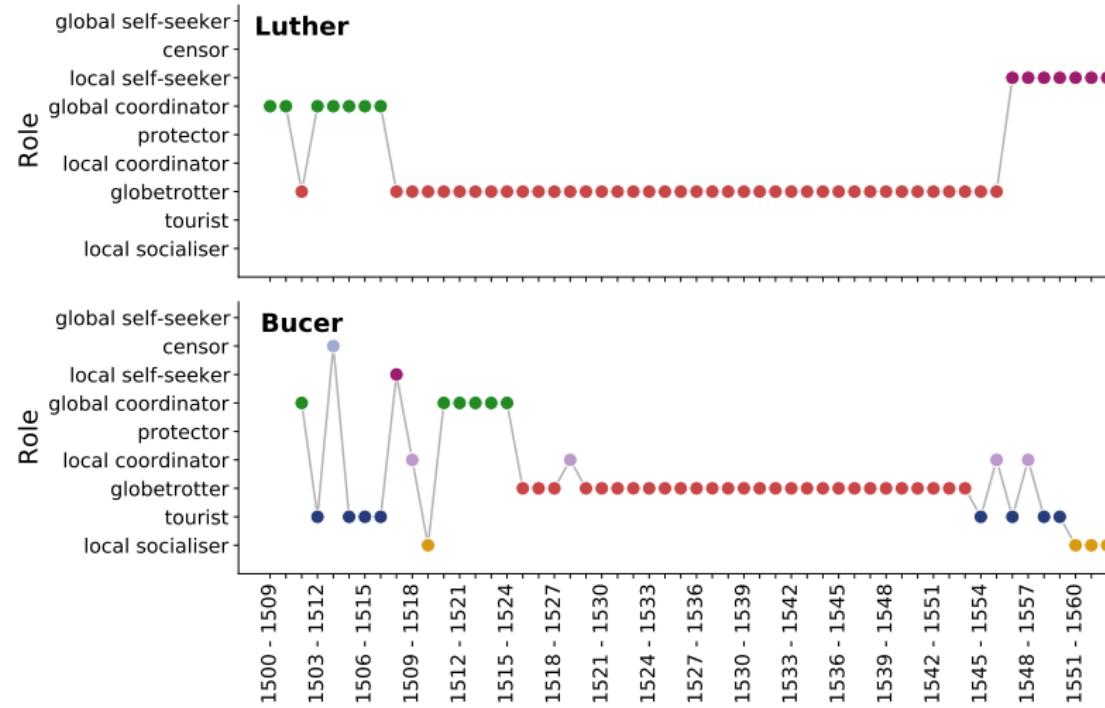
Going further

- ▶ So far: Analyse system level
- ▶ Now: Analyse individual level



⌚ Which roles did reformers fulfill over time? Why did they switch?

Analysing roles of individuals



⌚ **Luther: before vs. after theses, misdated letter**

⌚ **Bucer: monk, outlaw, mediator, England**

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