

Role detection in networks

Social differentiation during the
Reformation

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July 1, 2021



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

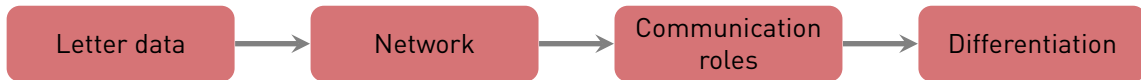


The rest

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

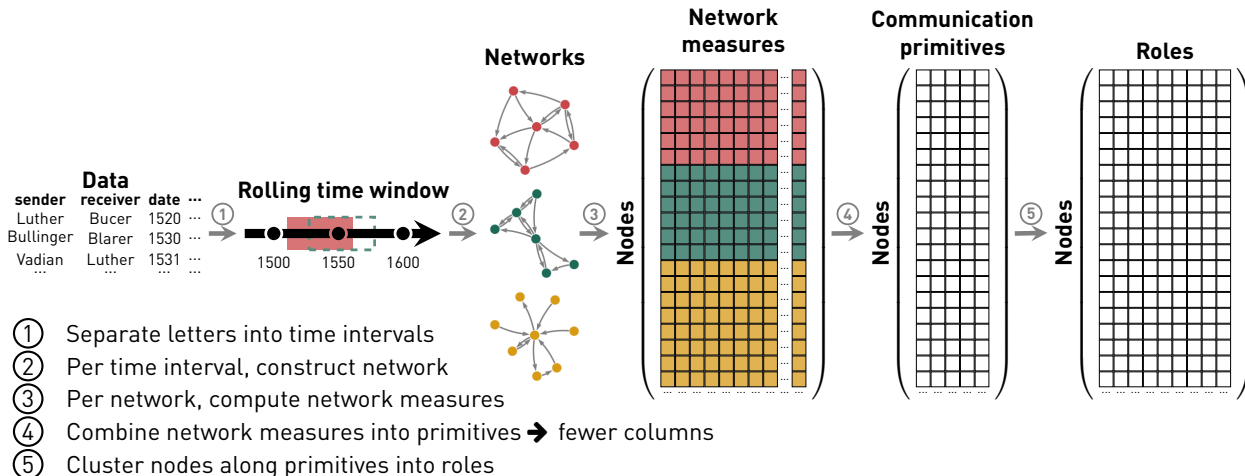


Myconius



Oekolampad

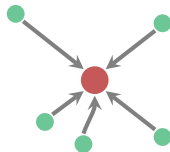
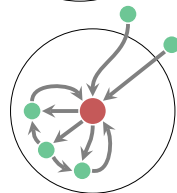
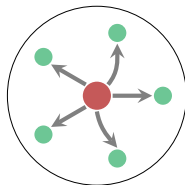
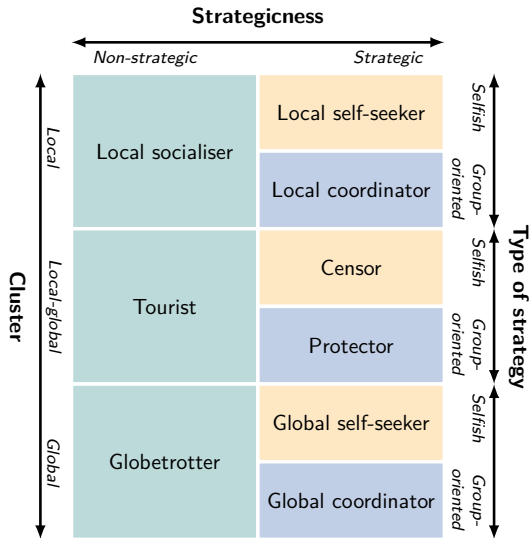
How to compute communication roles?



👉 **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

Reformer per time interval			Local socialiser	Tourist	Globetrotter	Local coordinator	Protector	Global coordinator	Local socialiser	Censor	Global self-seeker
	Reformer	Time interval									
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
...

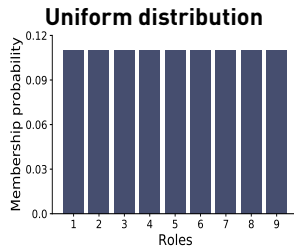
➡ For each reformers and time interval compute membership probability per role

How to measure differentiation?

Reformer per time interval

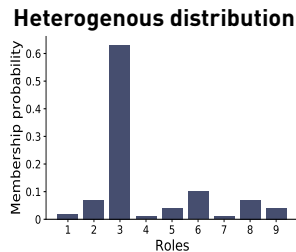
		Membership probability per role								
Luther	1500 – 09	0.11	0.11	0.11	0.11	0.13	0.11	0.11	0.11	0.11
Bucer	1500 – 09	0.02	0.07	0.63	0.01	0.04	0.10	0.01	0.07	0.04
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...

not differentiated



- ➡ Equal probabilities across roles
- ➡ Large entropy

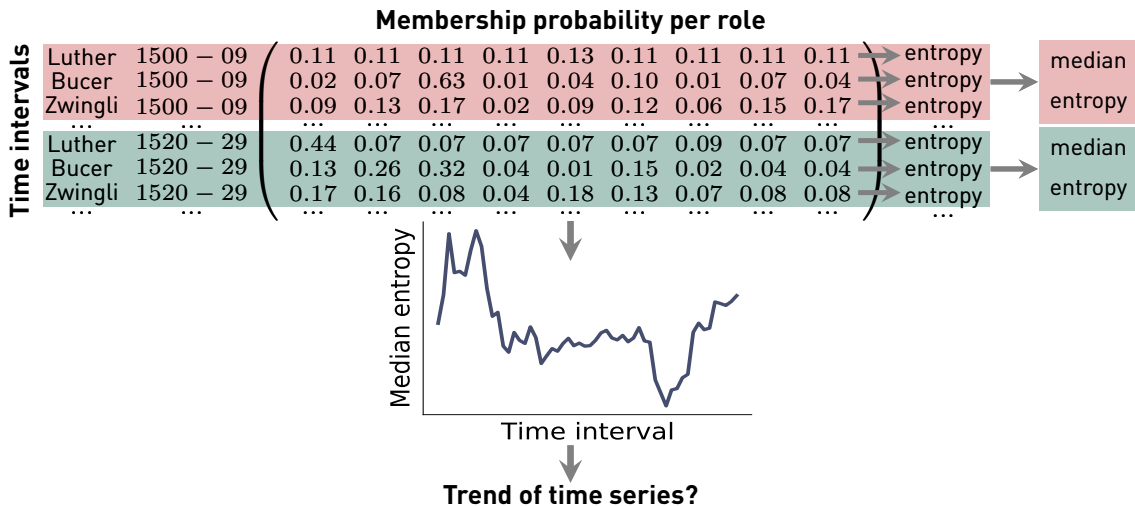
differentiated



- ➡ 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

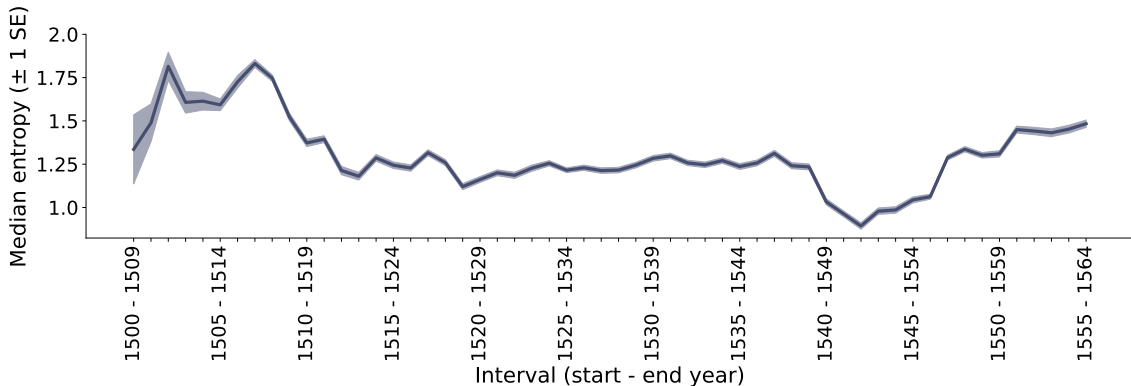
How to measure differentiation over time?



➡ **Differentiation: median entropy has to *decrease* over time**

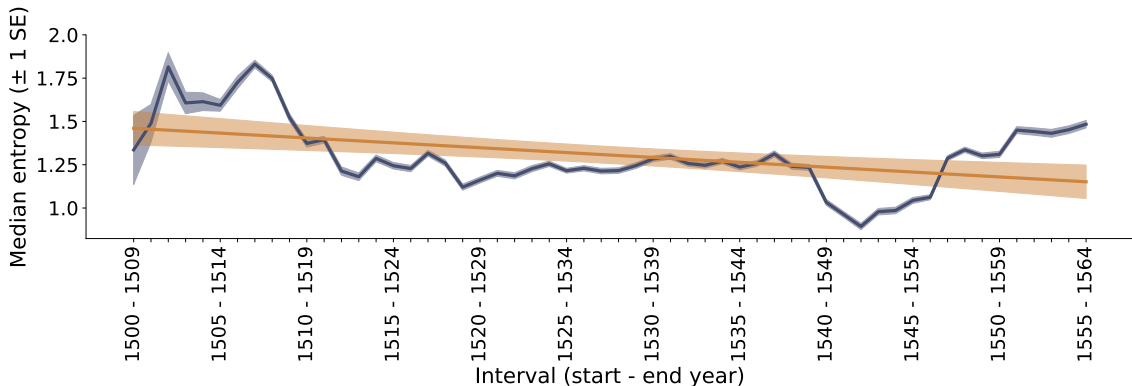
Entropy time series

- ▶ Median entropy of reformers' role membership probabilities over time
- ▶ To test: Negative trend → reformers become more specialised in their roles → differentiation



Trend of entropy time series: simple model

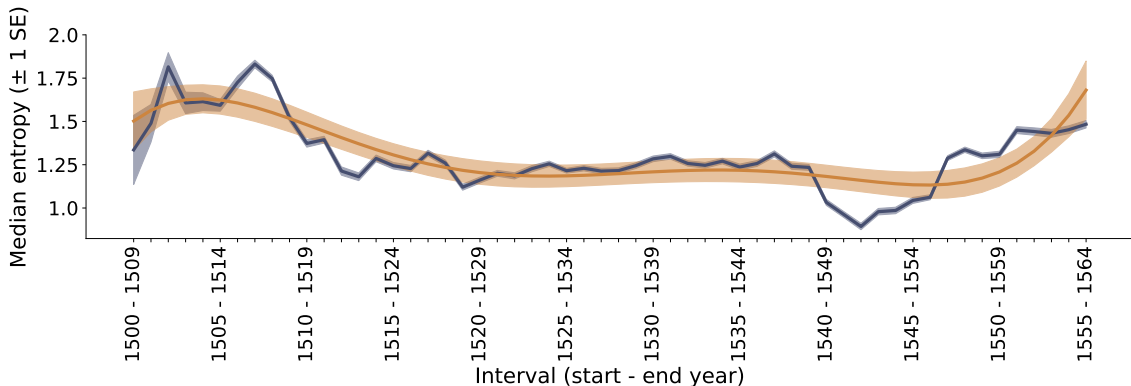
- ▶ **Fitted model:** Linear regression, $x = \text{time interval}$, β_1 : general trend
- ▶ median entropy = $\beta_0 + \beta_1 x$



👉 $\beta_1 = -0.006$ → negative trend

Trend of entropy time series: complex model

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



📌 $\beta_1 = -0.68$ → negative trend

Trend of entropy time series: comparing models

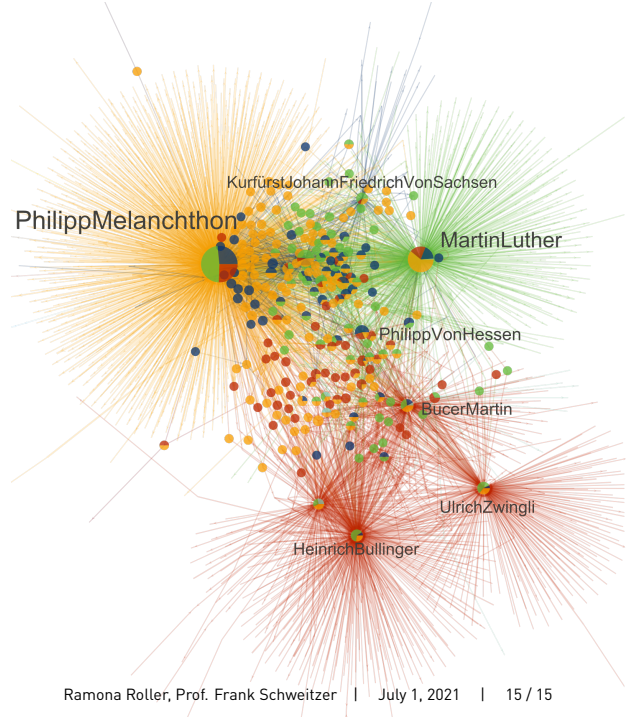
	simple model	complex model
Intercept	1.461 (0.048) ^{***}	1.306 (0.016) ^{***}
term 1	-0.006 (0.002) ^{***}	-0.680 (0.121) ^{***}
term 2		0.862 (0.121) ^{***}
term 3		0.228 (0.121)
term 4		0.123 (0.121)
term 5		0.506 (0.121) ^{***}
R ²	0.204	0.675
Adj. R ²	0.190	0.643
Num. obs.	56	56

^{***} $p < 0.001$; ^{**} $p < 0.01$; ^{*} $p < 0.05$

- ➡ Both models show significant negative trend of entropy time series
- ➡ Reformers become more differentiated in their communication roles

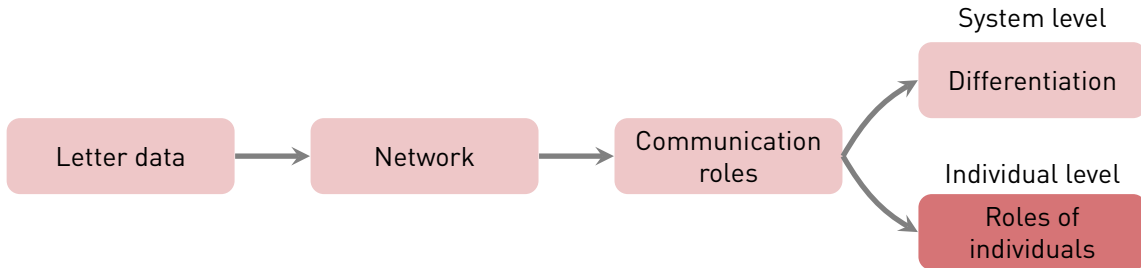
Summary

- ▶ **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**



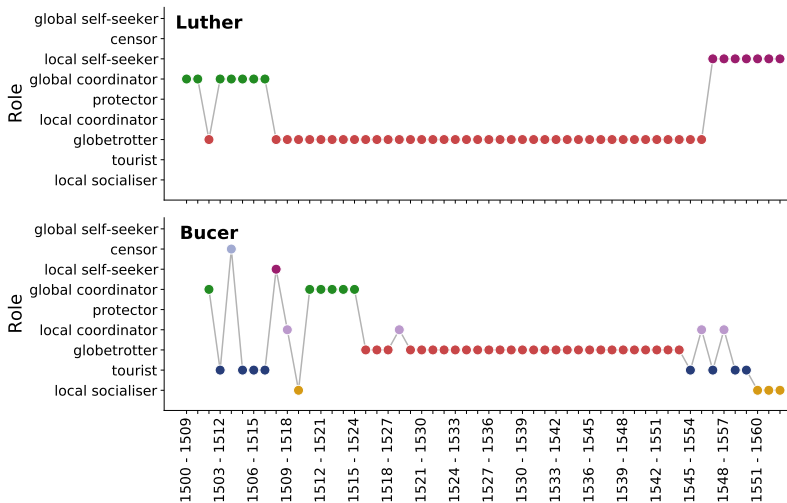
Going further

- ▶ 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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