The Evolution of A Digital Ecosystem: A Case of WordPress from 2004 to 2014

SungYong Um *

Youngjin Yoo **

Sunil Wattal ***

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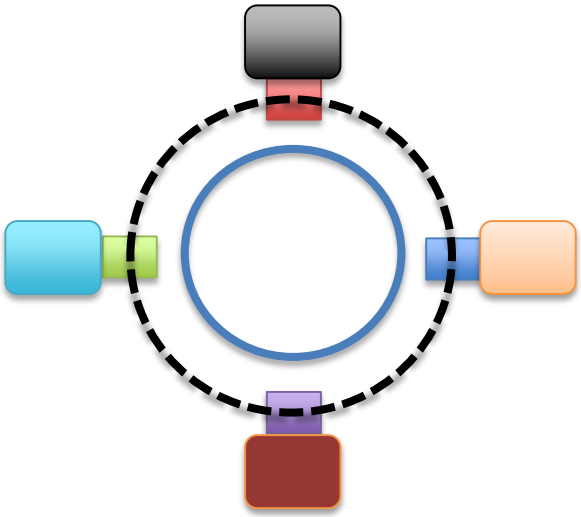
Research Background

- A digital ecosystem consists of:
  - Platform (e.g. Google & Wordpress)
  - Boundary resources
    (e.g. API & SDK)
  - Complementary products developed
    by third party developers
    (e.g. Applications & Plug-ins)



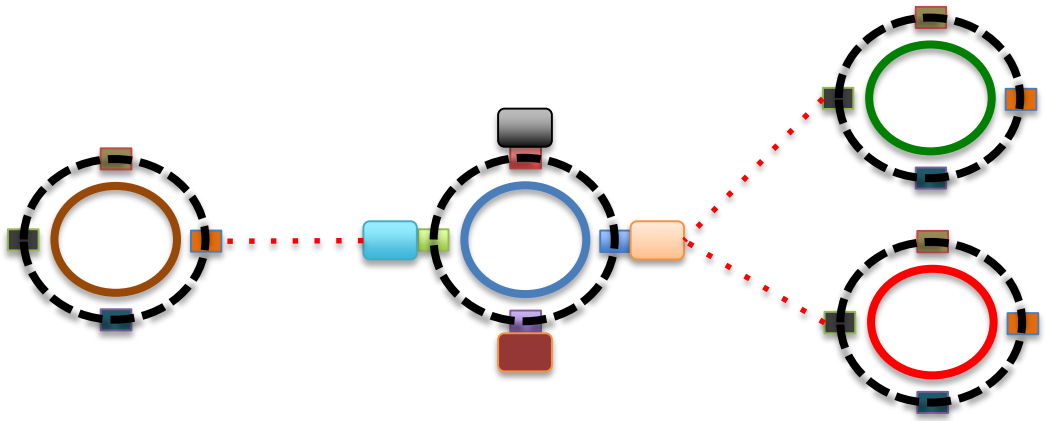
(Boudreau 2010, Ceccagonoli et al. 2012, Eaton et al. 2015
Ghazawneh & Henfridsson 2013, Tiwana et al. 2010, Yoo et al. 2010)

Research Background

- The nature of a digital ecosystem
  - Layered Modular Architecture

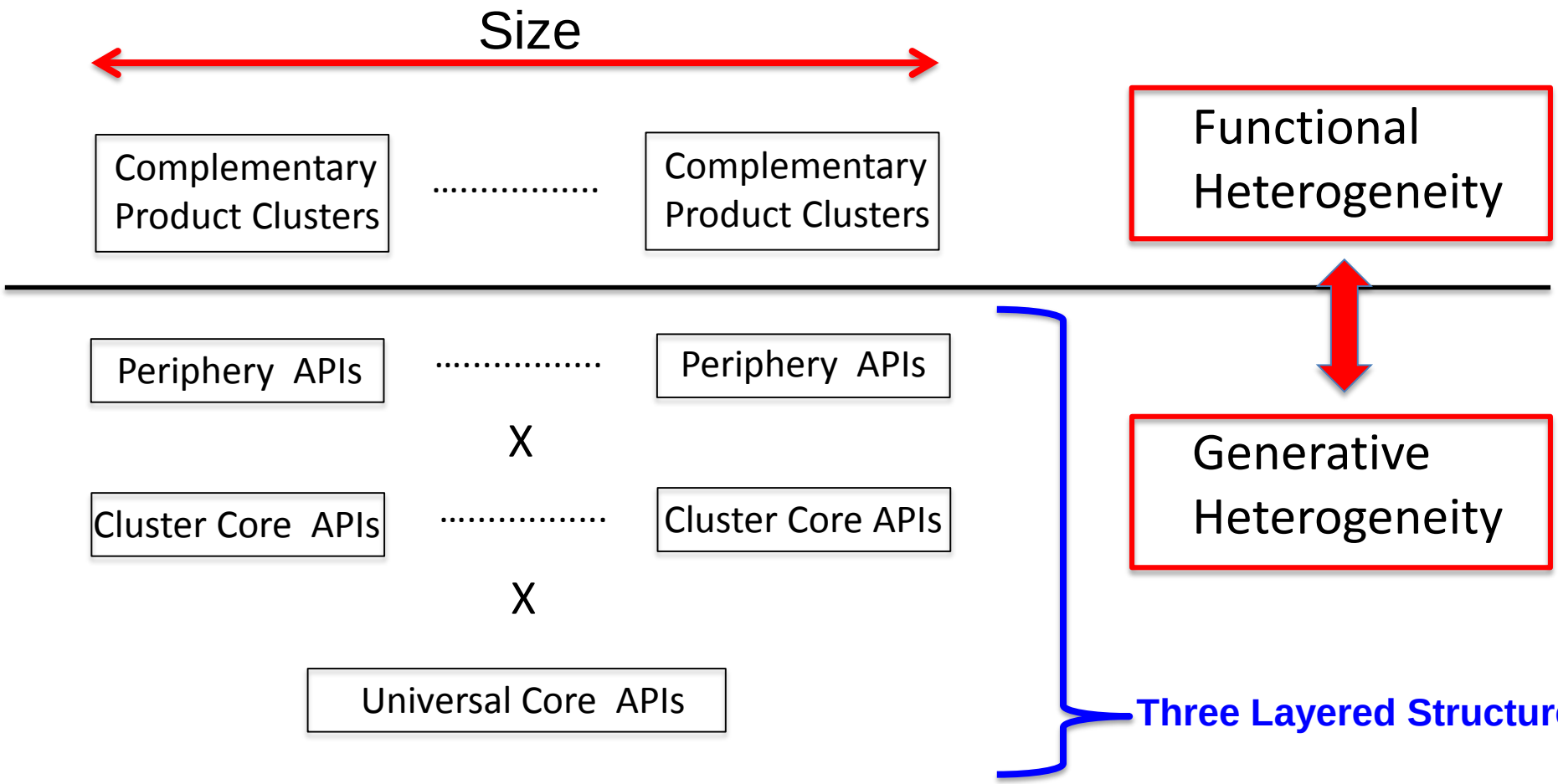
    : Uncoordinated design by third party developers

    with loose control by a platform provider



(Boudreau 2010, Chesbrough 2006, Eisenman et al. 2006,
Ghazawneh & Henfridsson 2013, Von Hippel 2003, Yoo et al. 2010, Zittrain 2006)

Structure of Ecosystem



(Um et al. 2015)

Research Question

What are the roles of different digital components in the growth of a digital ecosystem in heterogeneity and size?

WordPress

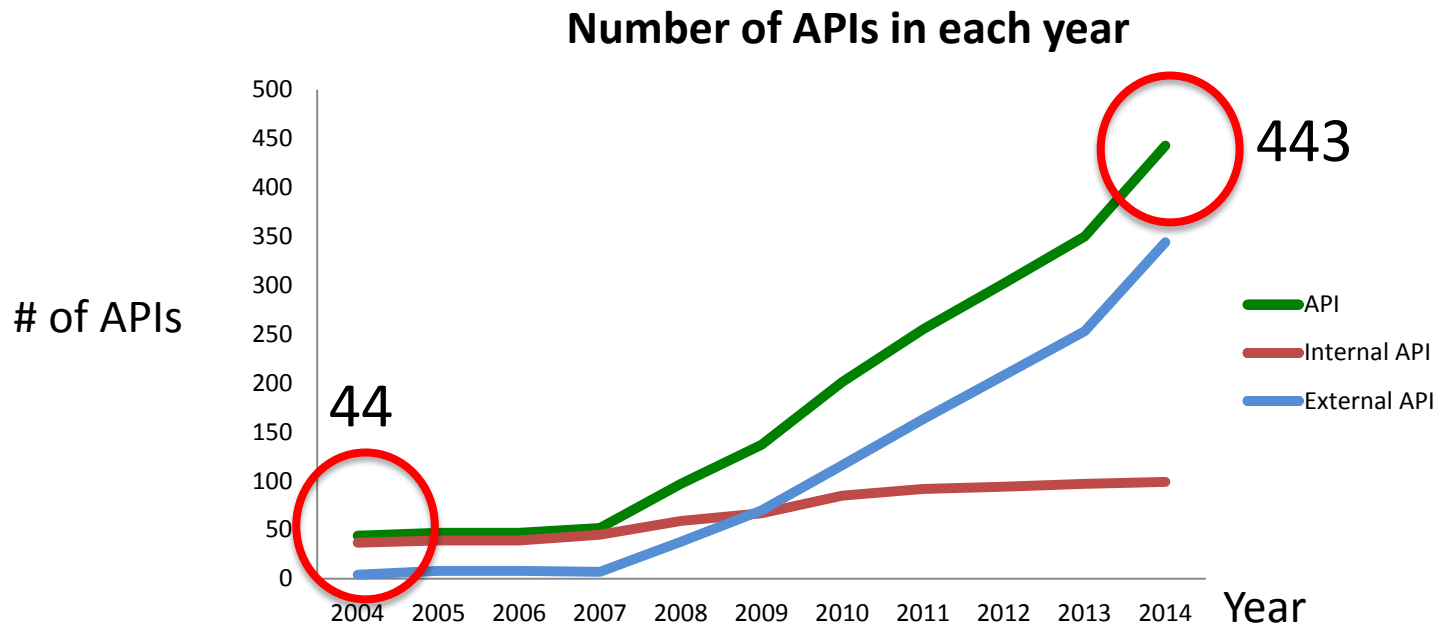
WordPress is web software you can use to create a beautiful website, blog, or app. We like to say that WordPress is both free and priceless at the same time.

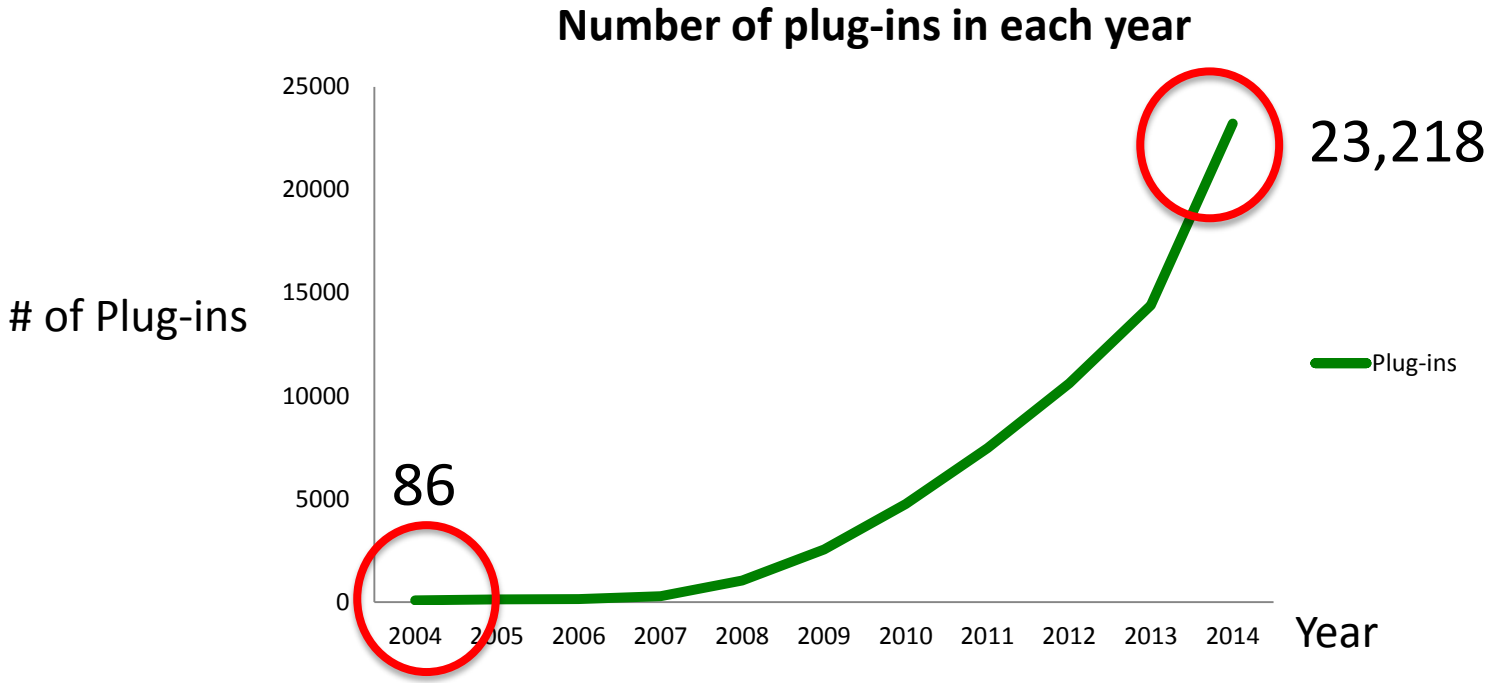
The core software is built by hundreds of community volunteers, and when you're ready for more there are thousands of plugins and themes available to transform your site into almost anything you can imagine. Over 60 million people have chosen WordPress to power the place on the web they call "home" — we'd love you to join the family.

SEARCH

Pages

- About me
- Presentations


Number of APIs in each year
# of APIs
500
450
400
350
300
250
200
150
100
50
0
44
443
API
Internal API
External API
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
Year


Number of plug-ins in each year
# of Plug-ins
25000
20000
15000
10000
5000
0
86
23,218
Plug-ins
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
Year

Growth of Ecosystem

Year												Internal API	External API	Total Plugin
2004	86	0	0	0	0	0	0	0	0	0	0	40	4	86
2005	139	0	0	0	0	0	0	0	0	0	0	42	5	139
2006	150	0	0	0	0	0	0	0	0	0	0	42	5	150
2007	298	0	0	0	0	0	0	0	0	0	0	45	7	298
2008	328	724	0	0	0	0	0	0	0	0	0	59	38	1052
2009	564	1998	0	0	0	0	0	0	0	0	0	67	70	2562
2010	500	1860	1485	925	0	0	0	0	0	0	0	85	116	4770
2011	1775	1961	1752	1053	942	0	0	0	0	0	0	92	163	7483
2012	2304	2297	2179	1632	1507	696	0	0	0	0	0	94	208	10615
2013	2473	2796	2720	1730	1270	1248	1140	1032	0	0	0	97	253	14409
2014	3080	3257	2561	2319	2161	2102	1934	1808	1737	1272	897	99	344	23218

Illustration: Ecosystem Growth

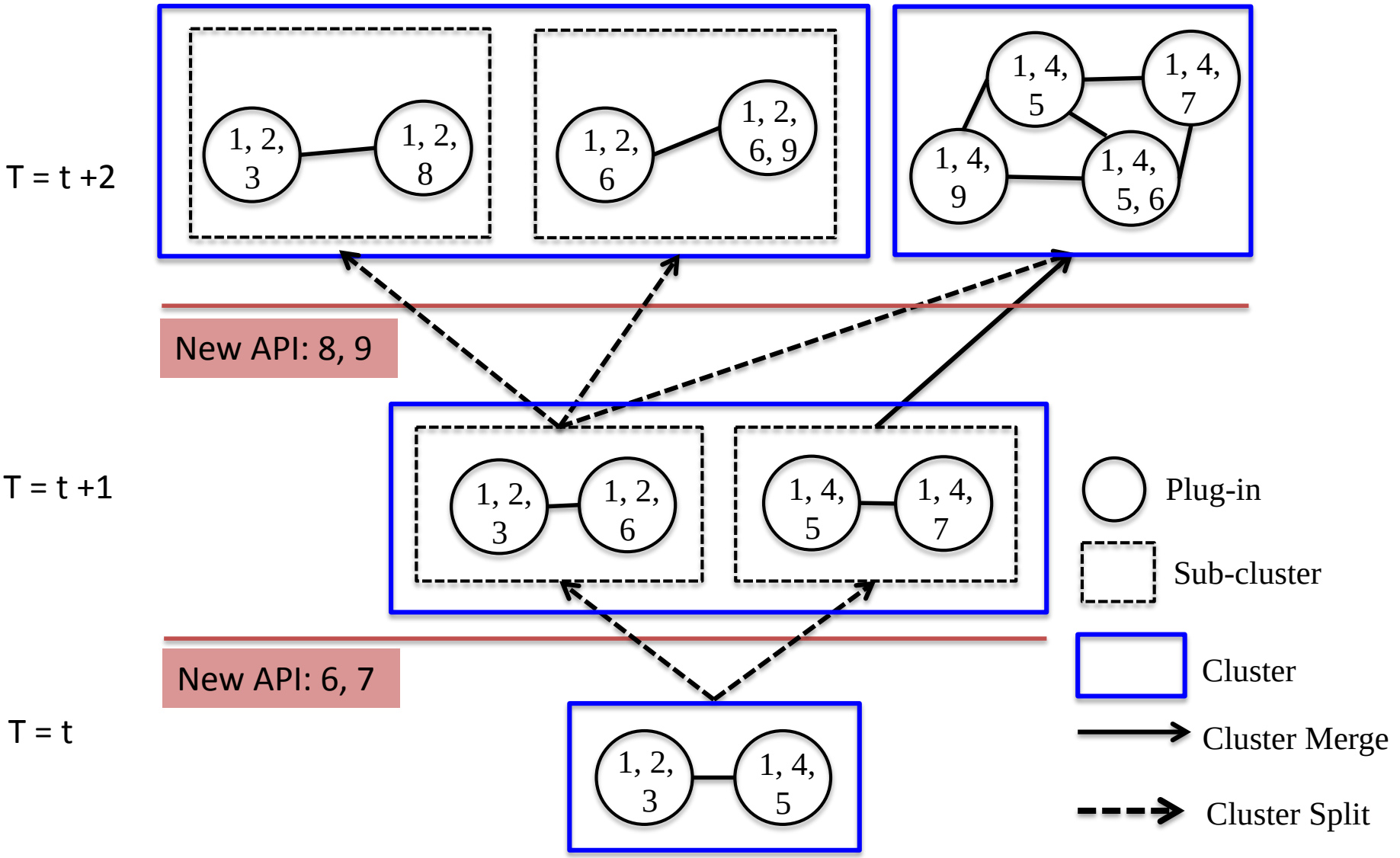
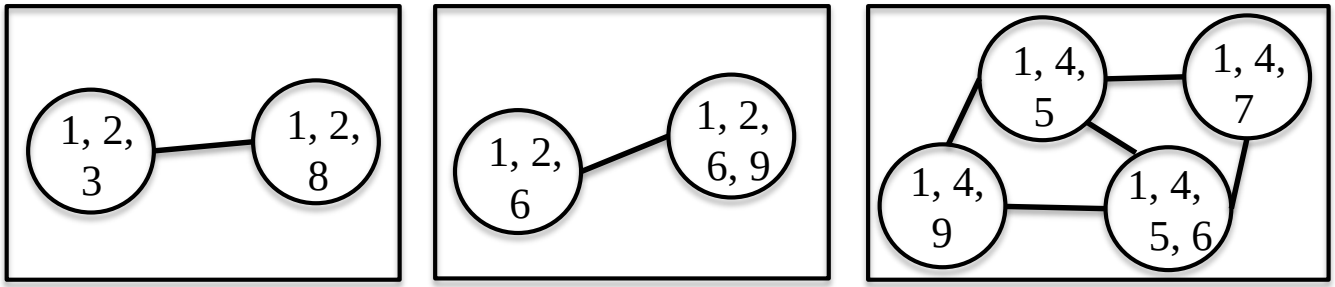
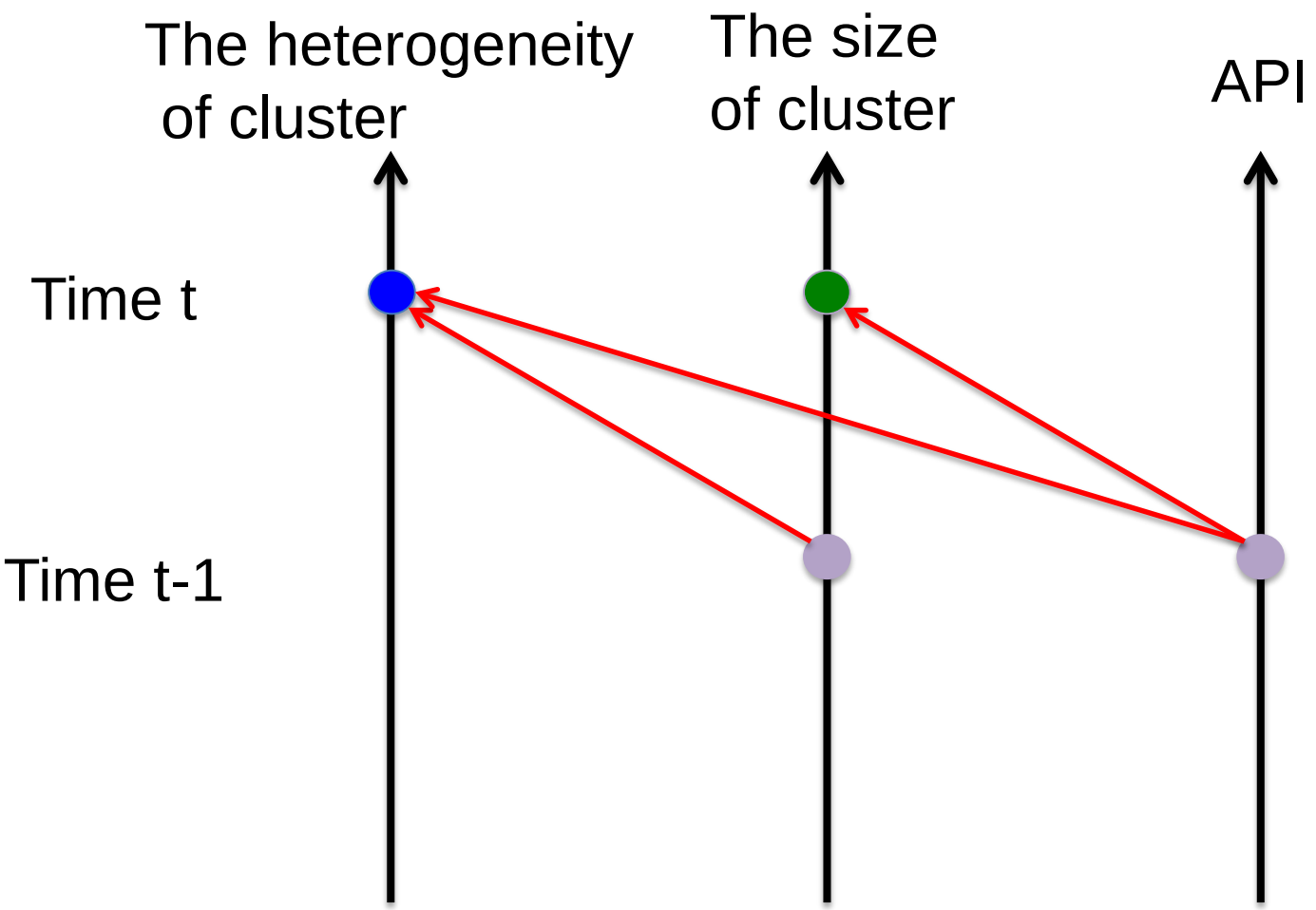


Illustration: Ecosystem Growth



Universal Core	1	1	1
Cluster Core	2	2, 6	4
Periphery	3, 8	9	5, 6, 7, 9

Illustration: Ecosystem Growth



Hypotheses

H1a: The number of cluster core components of a cluster positively affects the size of the cluster.

H1b: The impact of cluster core components on the cluster size follows a curvilinear (inverted U-shaped) form.

Hypotheses

H2a: The number of periphery components of a cluster positively affects the size of the cluster.

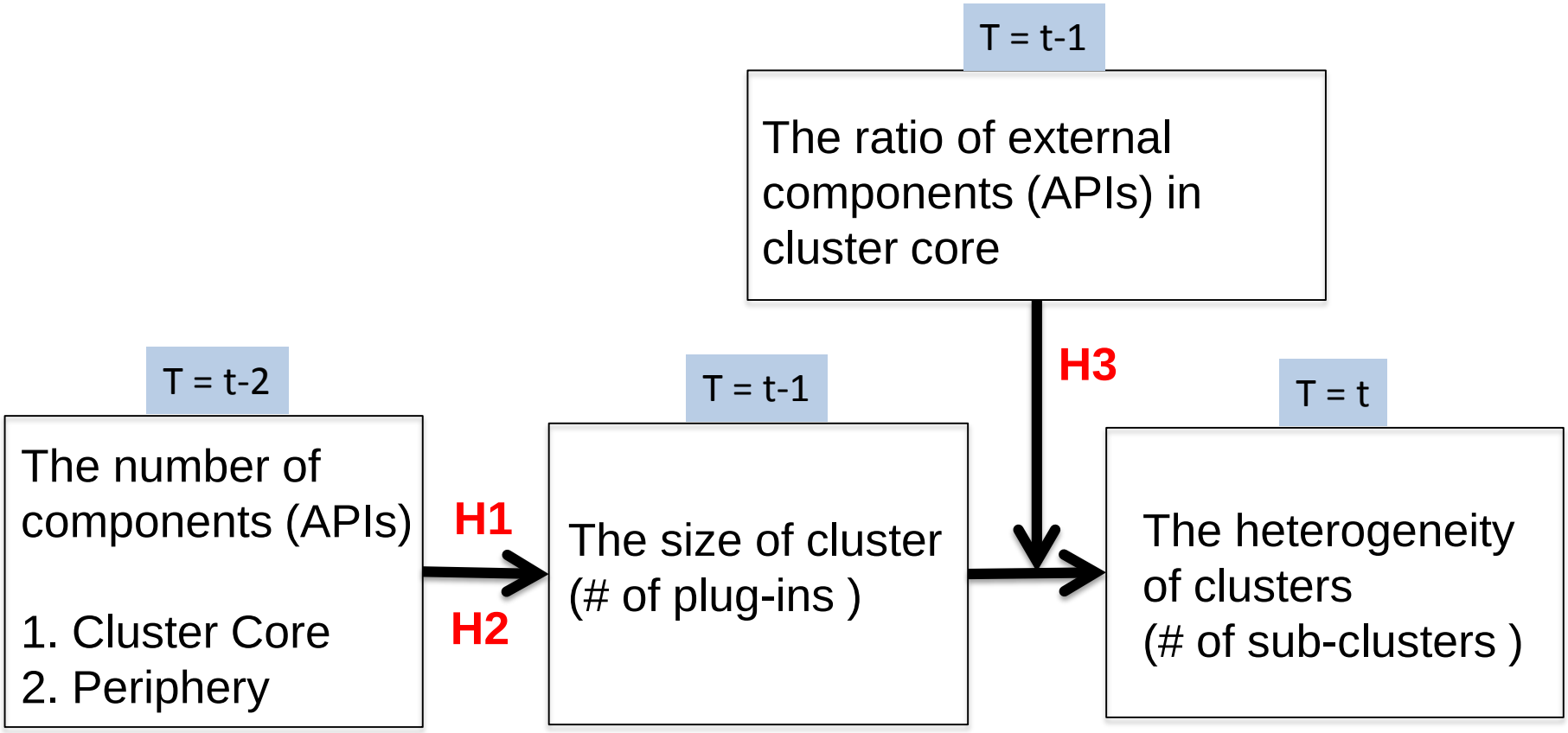
H2b: The impact of periphery components on the cluster size follows a curvilinear (inverted U-shaped) form.

Hypotheses

H3a: The ratio of external cluster core components positively affects the heterogeneity of sub-clusters of a cluster.

H3b: The impact of external cluster core components on the heterogeneity of sub-clusters is negatively moderated by the size of the cluster.

Hypotheses



* Unit of analysis: cluster

Time Series Model

Model 1 for H1 & H2:

$$\#of\_Plugin_{i(t-1)} = \beta_0 + \beta_1(\#of\_APIs\_in\_cluster\_core)_{i(t-2)} + \beta_2(\#of\_APIs\_in\_Periphery)_{i(t-2)}$$
$$+\beta_3(\#of\_APIs\_in\_cluster\_core)^2_{i(t-2)} + \beta_4(\#of\_APIs\_in\_periphery)^2_{i(t-2)}$$
$$+(Control\_Variables)_{i(t-2)} + \alpha_i + \phi_t + \varepsilon_{it}$$

Model 2 for H3:

$$\#of\_subcluster_{it} = \beta_0 + \beta_1(\#of\_plugin)_{i(t-1)} + \beta_2(ratio\_of\_externalAPIs)_{i(t-1)}$$
$$+\beta_3(\#of\_plugin * ratio\_of\_externalAPIs)_{i(t-1)} + (Control\_Variables)_{i(t-1)} + \alpha_i + \phi_t + \varepsilon_{it}$$

Time Series Model

Model 3 for full time series test:

$$\#\,of\_subcluster_{it} = \beta_0 + \beta_1(\#\,of\_plugin)_{i(t-1)} + \beta_2(ratio\_of\_externalAPIs)_{i(t-1)}$$
$$+\beta_3(\#\,of\_plugin * ratio\_of\_externalAPIs)_{i(t-1)} + \beta_4(\#\,of\_APIs\_in\_cluster\_core)_{i(t-2)}$$
$$+\beta_5(\#\,of\_APIs\_in\_Periphery)_{i(t-2)} + \beta_6(\#\,of\_APIs\_in\_cluster\_core)^2_{i(t-2)}$$
$$+\beta_7(\#\,of\_APIs\_in\_Periphery)^2_{i(t-2)}$$
$$+(Control\_Variables)_{i(t-1)} + (Control\_Variables)_{i(t-2)} + \alpha_i + \phi_t + \varepsilon_{it}$$

Variable Description

- **Dependent variables**

The heterogeneity of clusters
: the total number of sub-clusters in each cluster

The size of cluster
: the total number of plug-ins in each cluster

- **Independent variables**

The number of cluster core digital components
: the total number of APIs categorized into cluster core in each cluster

The number of periphery digital components
: the total number of APIs categorized into periphery in each cluster

The ratio of external cluster core components
: (the number of external APIs / the total number of APIs) in cluster core

Variable Description

- **Control variables**

plug-in / developer
: (the total number of plug-ins / the total number of developers) in each cluster

avg_plug-in_age
: (the sum of all plug-in age/ the total number of plug-ins) in each cluster

avg_version update
: (the total number of version upgrade/ the total number of plug-ins)
in each cluster

Variable Description

Variables	Mean	Std. Dev.	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)
(a) hierarchy	8.665	4.730	1.000							
(b) plugin	1478.905	846.842	0.661	1.000						
(c) cluster core API	28.012	24.920	0.798	0.458	1.000					
(d) periphery API	81.520	37.096	0.534	0.821	0.286	1.000				
(e) ratio_of_externalAPI	5.741	7.831	0.481	0.676	0.523	0.537	1.000			
(f) plugin/developer	1.793	0.161	-0.081	0.118	-0.026	0.074	0.150	1.000		
(g) avg_plugin_age	58.728	28.709	-0.423	-0.656	-0.120	-0.793	-0.339	0.370	1.000	
(h) avg_version_upgrade	0.038	0.027	0.117	-0.106	0.093	-0.074	-0.107	-0.056	-0.015	1.000

Results

	Model 1 plugin(t-1)	Model 2 sub-cluster (t)	Model 3 sub-cluster (t)
plugin(t-1)	x	.007(0.001)***	.005(.001)***
ratio_externalAPI (t-1)	x	.238(0.049)***	.038(.055)
plugin(t-1) X externalAPI (t-1)	x	-.0001(0.0001)***	-.00001(.00001)*
plugin/developer (t-1)	x	-2.327(1.414)***	-.038(1.797)
avg_plugin_age (t-1)	x	-.099(0.036)***	-.009(.037)
avg_version_upgrade (t-1)	x	24.205(12.828)***	-.006(.007)
cluster core API (t-2)	-4.916(2.568)*	x	.034(.027)
periphery API (t-2)	13.440(3.873)***	x	.314(.037)***
(cluster core API)^2 (t-2)	.126(.018)***	x	.0001(.00001)
(periphery API)^2 (t-2)	-.063(.02)***	x	-.002(.00001)***
plugin/developer (t-2)	536.852(176.071)***	x	-2.954(1.732)*
avg_plugin_age (t-2)	5.374(3.785)	x	-.074(.036)*
avg_version_upgrade (t-2)	-1632.788(1380.093)	x	-.008(.007)
Constant	- 1812.517(729.26)**	15.109(6.706)**	10.667 (8.173)
R Square	0.682	0.525	0.616
Obs	411	422	411
Time Fixed Effects	Yes	Yes	Yes
Cluster Fixed Effects	Yes	Yes	Yes

Findings

1. The impact of cluster core APIs on the size of the cluster follows the U-shape, while the impact of periphery follows the inverted U-shape.

2. The introduction of external APIs increases the heterogeneity of sub-clusters when the size of the cluster is small.

1. The impact of external APIs and periphery APIs on the heterogeneity of sub-clusters are partially mediated.

Discussion and Implication

1. Increasing the number of third party developers is limited to diversify the structural heterogeneity of digital ecosystem.

2. Platform owners need to decide the time point when the core platform functionality is opened.

3. The role of external APIs is not limited but changes the design pattern of a digital ecosystem.

Limitations

1. Limited to third party developers' information
2. Limited to consider demand side
3. Limited to one digital ecosystem

Questions