Partly Cloudy: Now & Forever

Migrating to a Cloud-Based IT Infrastructure in a Grant-Funded Research Environment: *Challenges and Limits*

Robert J. Robbins

RJR8222@gmail.com

(http://www.rj-robbins.com/slides/RJR-PCNF-2018.pdf)

Full Disclosure:

- Who am I:
  - A PhD biologist, with career-long increasing involvement with IT: former university faculty, former agency program officer, former VP/IT @ FHCRC See: www.rj-robbins.com & www.esp.org
- My background-based conceptual framework:
  - Patterns of cash flows tend to shape institutional behavior.
  - Publically funded, non-profit research institutions are their own entity; they are not merely badly run for-profit enterprises.

Abstract:

Cloud computing is coming, and coming fast. Some estimates show the market for cloud services growing at 25% per year. Cloud computing is perhaps the most fundamental and profound change yet to occur in IT. Compared with other endeavors, computing is still an incredibly immature activity, characterized by learn as you go methods — much as characterized the early days of medieval church architecture: that looks good; like the new dome; oops, it fell down; wonder why?

Cloud computing represents a major maturational step for computing in general, abstracting away most of the lower layers from the necessary attention of users. It is the future of computing.

And yet…

And yet, will it, can it work in a biomedical research environment? Do the cloud-computing advantages that are so obvious in the for-profit sector (agility, almost unlimited scalability) apply as well (or work at all) in a grant-funded research environment?

What are the attributes of the grant-funded research environment that raise issues, pose challenges, possibly create limits to the full deployment of cloud computing in that environment?

Partly Cloudy: Now & Forever

- Historical Computing: CDC 6500
- Cloud Computing
- How Do Grants Actually Work?
- Porter Competitive Advantage Model (what is and what affects **The Bottom Line** in Grant Funded Research?)
- How Different is Research IT? A Few Dialogues
- Understanding Research (operational practices, cultural norms, IT)
- Conclusions: Going Forward

Historical Computing

CDC 6500

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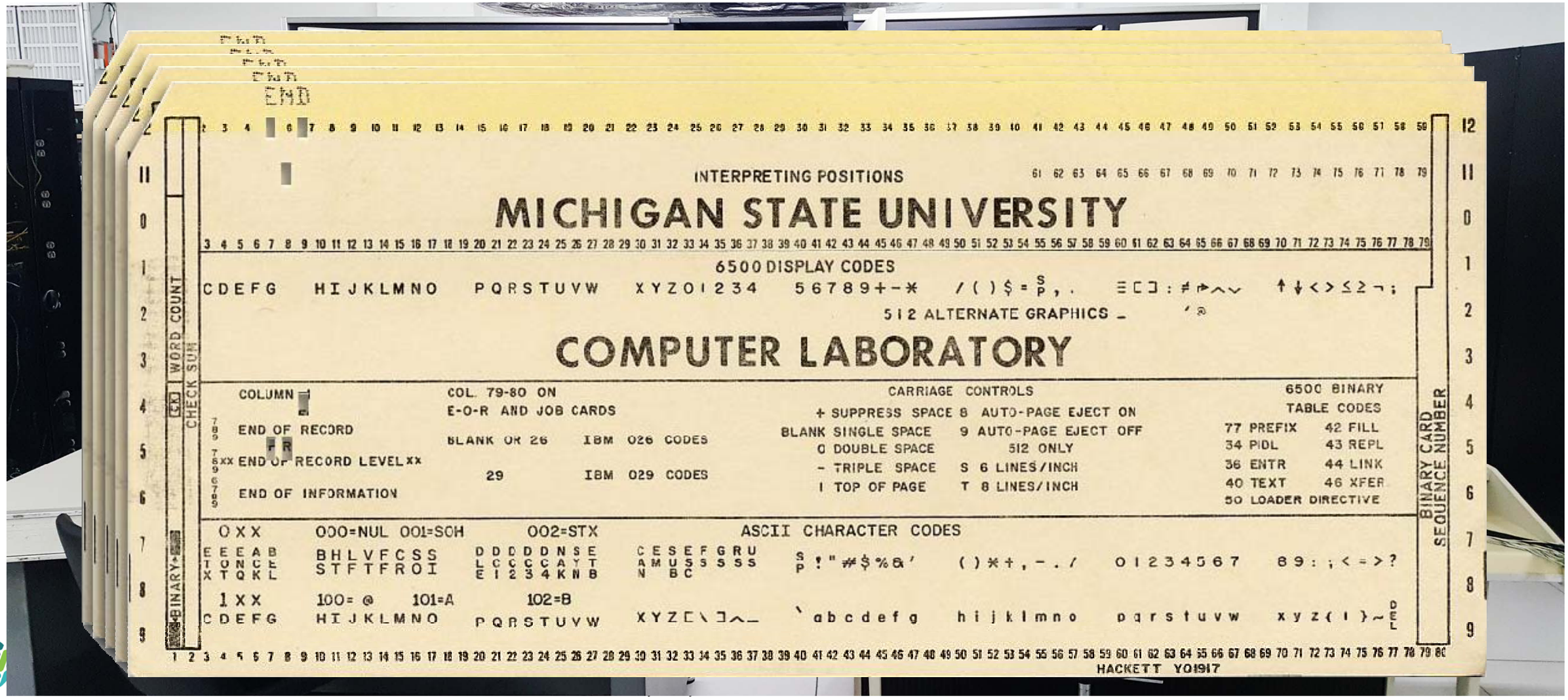

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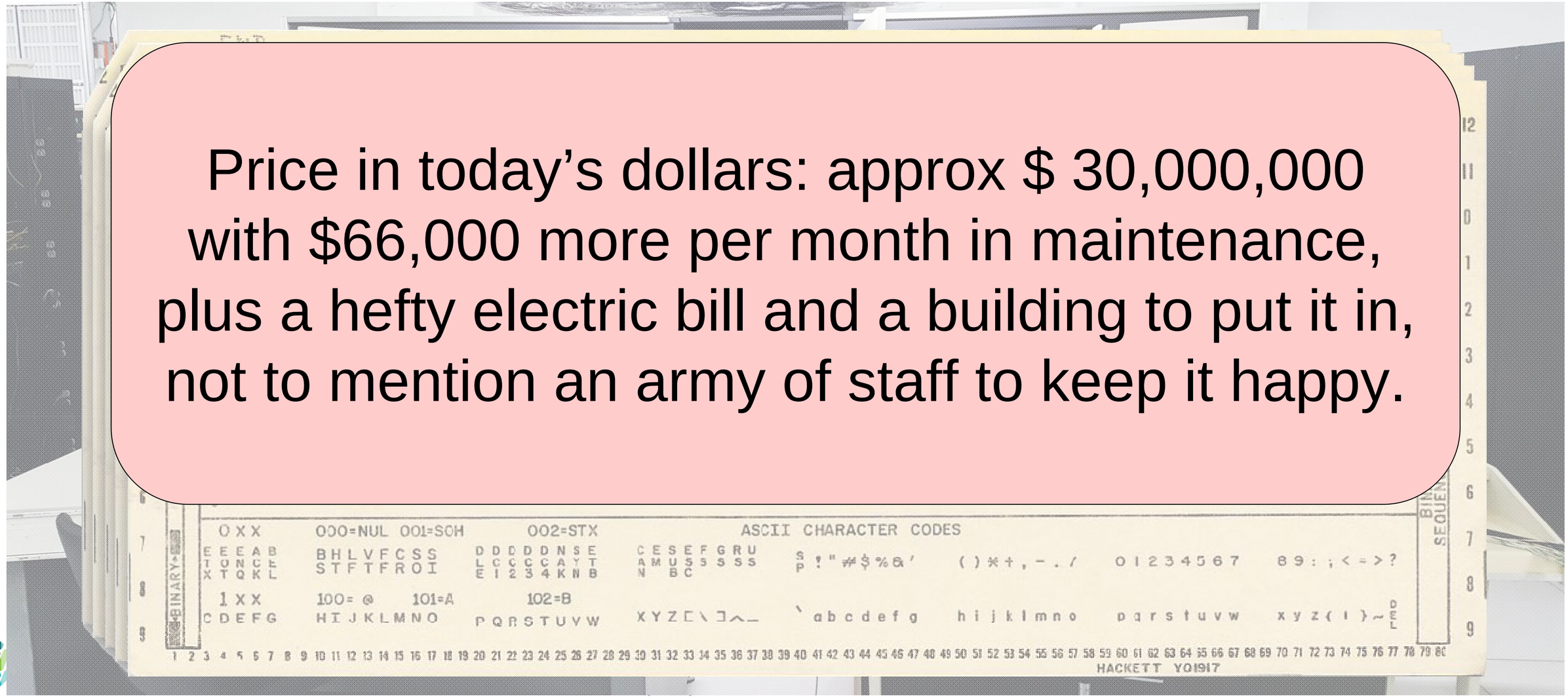

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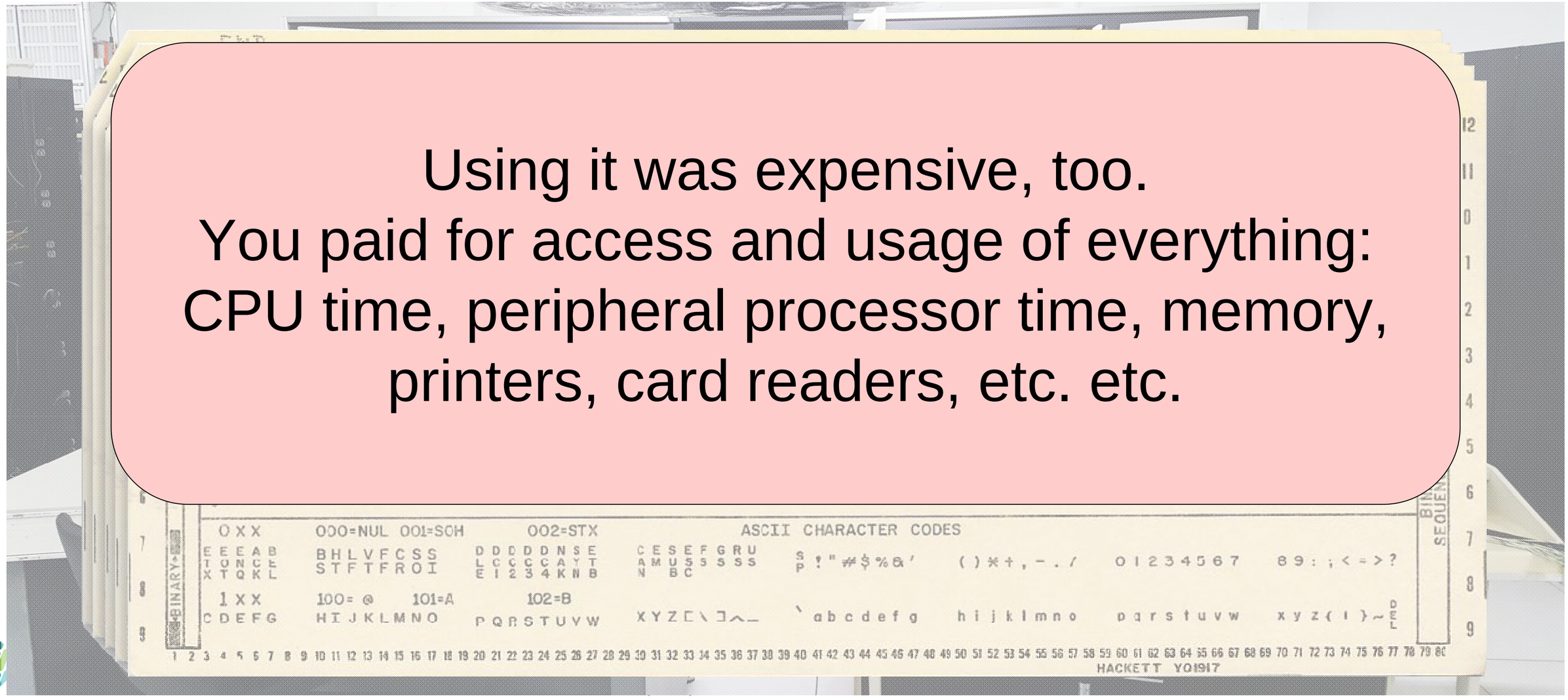

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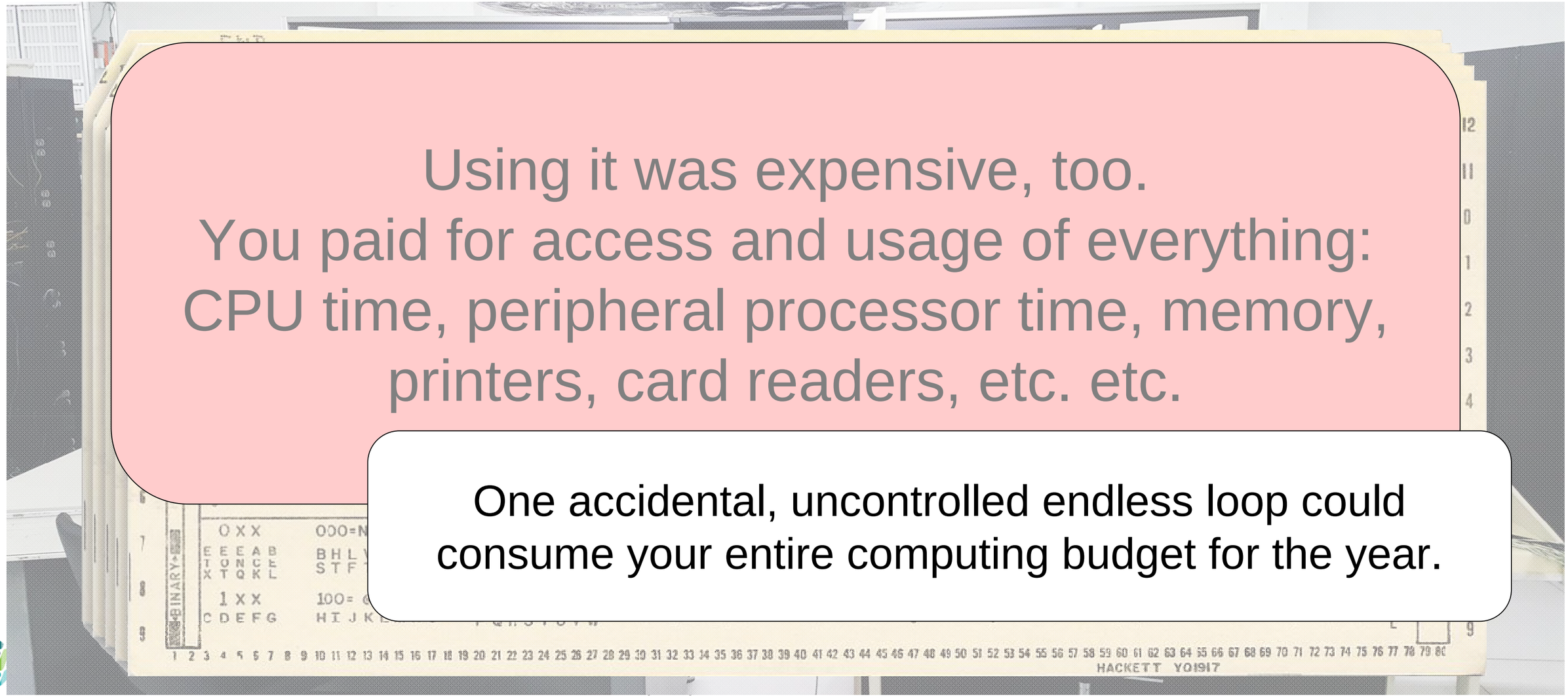

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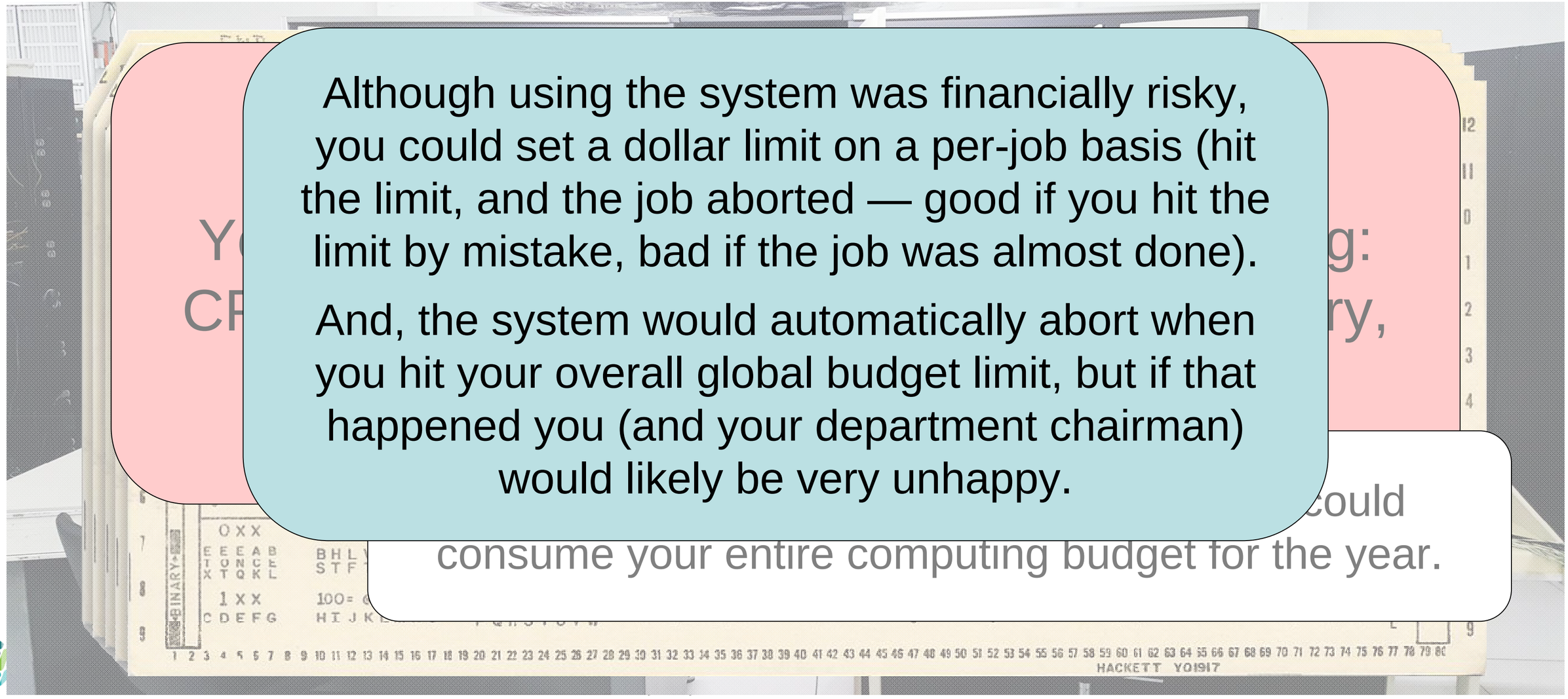


Although using the system was financially risky, you could set a dollar limit on a per-job basis (hit the limit, and the job aborted — good if you hit the limit by mistake, bad if the job was almost done).

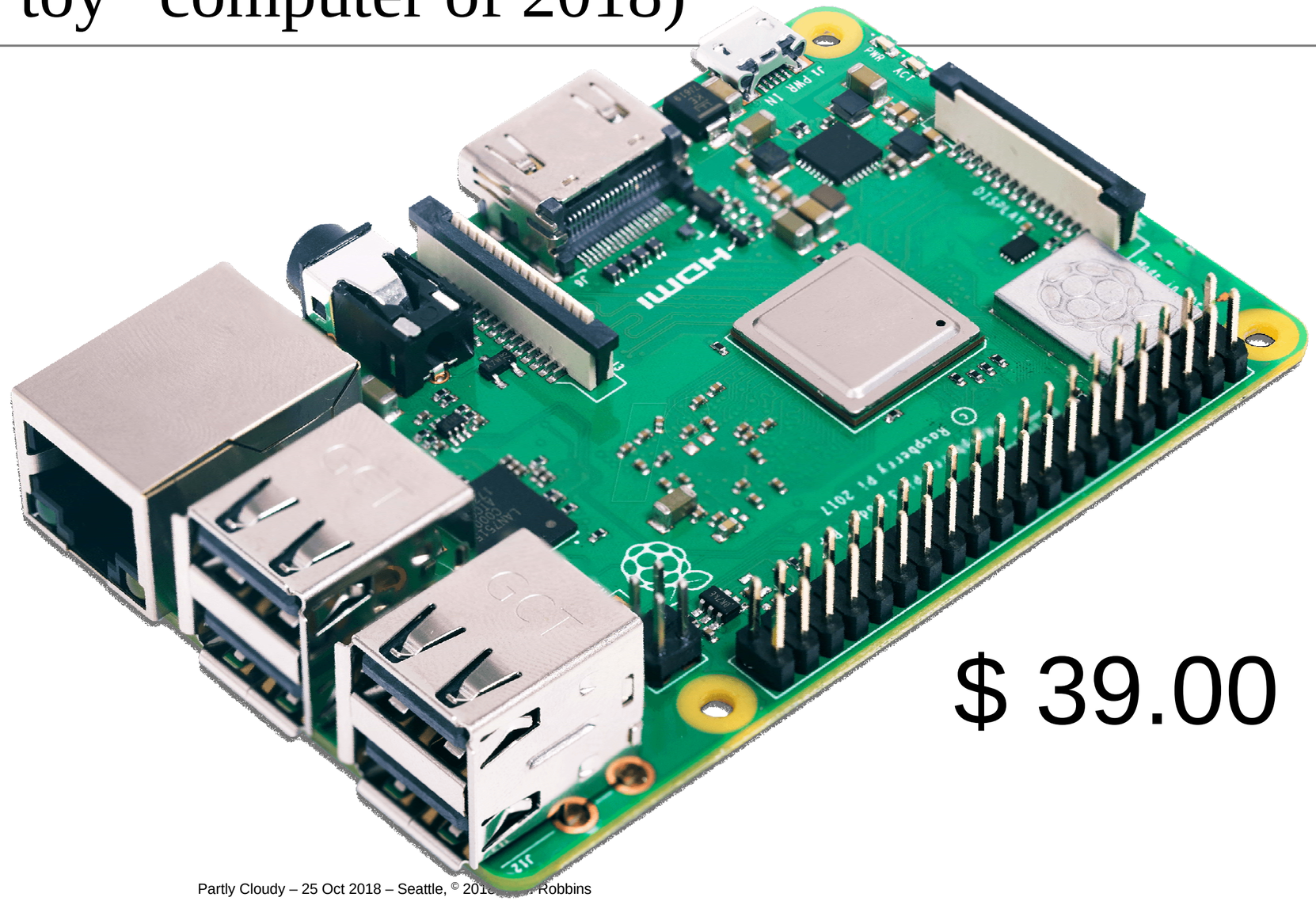
And, the system would automatically abort when you hit your overall global budget limit, but if that happened you (and your department chairman) would likely be very unhappy.

CDC 6500 (state of the art supercomputer in 1960s-1970s)

CPU:	CDC 6400 cpu (x2), 1 mega hertz
Memory:	128k 60-bit words (~ 1 meg modern standards)
Storage:	100 megabytes ($325,000 in 1968)
Cost:	$30,000,000 ($4,200,000 in 1968)
Power:	50,000 watts
Weight:	10,000 pounds
Support:	$ 66,400 / month ($8,968 in 1968).

Raspberry Pi 3B+ (“toy” computer of 2018)

$ 14.00



$ 39.00

Raspberry Pi 3B+ (“toy” computer of 2018)

CPU:	quad-core 64-bit 1 Ghz
Memory:	1 gig
Storage:	64 gig (micro-SD card, 64 gig = $14.00)
Cost:	$39 in today’s dollars
Power:	7 watts
Weight:	5 ounces
Support:	0

Raspberry Pi 3B+ *vs.* CDC 6500

CPU:	1,000x faster
Memory:	1,000x more
Storage:	1,000x more
Cost:	1,000,000x cheaper
Power:	5,000x less
Weight:	30,000x lighter
Support:	0 - (1,000x new units for one month CDC maintenance)

Raspberry Pi 3B+ *vs*. CDC 6500

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- Insatiable demand + unlimited supply = **financial danger**
- Skills at defensive computing are a hard requirement.
- Institutional support for financial prudence is highly desirable.

Cloud Computing

Cloud Computing — Definition

Wikipedia: Cloud computing is shared pools of configurable computer system resources and higher-level services that can be rapidly provisioned with minimal management effort, often over the Internet. Cloud computing relies on sharing of resources to achieve coherence and economies of scale, similar to a public utility.

Cloud Computing — Types

MS Azure:

- **Infrastructure as a service (IaaS)** : The most basic category of cloud computing services. With IaaS, you rent IT infrastructure—servers and virtual machines (VMs), storage, networks, operating systems—from a cloud provider on a pay-as-you-go basis.
- **Platform as a service (PaaS)**: Platform as a service refers to cloud computing services that supply an on-demand environment for developing, testing, delivering, and managing software applications. PaaS is designed to make it easier for developers to quickly create web or mobile apps, without worrying about setting up or managing the underlying infrastructure of servers, storage, network, and databases needed for development.
- **FaaS (functions as a service):** Overlapping with PaaS, FaaS serverless computing focuses on building app functionality without spending time continually managing the servers and infrastructure required to do so. The cloud provider handles the setup, capacity planning, and server management for you. FaaS serverless architectures are highly scalable and event-driven, only using resources when a specific function or trigger occurs.
- **Software as a service (SaaS)**: Software as a service is a method for delivering software applications over the Internet, on demand and typically on a subscription basis. With SaaS, cloud providers host and manage the software application and underlying infrastructure, and handle any maintenance, like software upgrades and security patching. Users connect to the application over the Internet, usually with a web browser on their phone, tablet, or PC.

Cloud Computing — Advantages

Amazon AWS:

- **Trade capital expense for variable expense**: Instead of having to invest heavily in data centers and servers before you use them, you can only pay when you consume computing resources, and only pay for how much you consume.
- **Benefit from massive economies of scale**: By using cloud computing, you can achieve a **lower variable cost** than you can get on your own.
- **Stop guessing capacity**: Eliminate guessing on your infrastructure capacity needs.
- **Increase speed and agility**: In a cloud computing environment, new IT resources are only ever a click away, which means you reduce the time it takes to make those resources available to your developers from weeks to just minutes. This results in a dramatic increase in agility for the organization, since the cost and time it takes to experiment and develop is significantly lower.
- **Stop spending money on running and maintaining data centers**: Focus on projects that differentiate your business, not the infrastructure.
- **Go global in minutes**: Easily deploy your application in multiple regions around the world with just a few clicks. This means you can provide a lower latency and better experience for your customers simply and at minimal cost.

Cloud Computing — Attributes

NIST:

- **On-demand self-service**. A consumer can unilaterally provision computing capabilities, such as server time and network storage, as needed automatically without requiring human interaction with each service provider.
- **Broad network access**. Capabilities are available over the network and accessed through standard mechanisms that promote use by heterogeneous thin or thick client platforms (e.g., mobile phones, tablets, laptops, and workstations).
- **Resource pooling**. The provider's computing resources are pooled to serve multiple consumers using a multi-tenant model, with different physical and virtual resources dynamically assigned and reassigned according to consumer demand.
- **Rapid elasticity**. Capabilities can be elastically provisioned and released, in some cases automatically, to scale rapidly outward and inward commensurate with demand. To the consumer, the capabilities available for provisioning often appear unlimited and can be appropriated in any quantity at any time.
- **Measured service**. Cloud systems automatically control and optimize resource use by leveraging a metering capability at some level of abstraction appropriate to the type of service (e.g., storage, processing, bandwidth, and active user accounts). Resource usage can be monitored, controlled, and reported, providing transparency for both the provider and consumer of the utilized service.

Cloud Computing — Attributes

Wikipedia:

- **Agility** for organizations may be improved, as cloud computing may increase users' flexibility with re-provisioning, adding, or expanding technological infrastructure resources.
- **Cost reductions** are claimed by cloud providers. A public-cloud delivery model **converts capital expenditures to operational expenditure**.
- **Productivity** may be increased when multiple users can work on the same data simultaneously, rather than waiting for it to be saved and emailed.
- **Reliability** improves with the use of multiple redundant sites, which makes well-designed cloud computing suitable for business continuity and disaster recovery.
- **Scalability** and elasticity via dynamic ("on-demand") provisioning of resources on a fine-grained, self-service basis in near real-time. Cloud providers typically use a "pay-as-you-go" model, which can lead to **unexpected operating expenses**.
- **Security** can improve due to centralization of data, increased security-focused resources, etc., but concerns can persist about loss of control over certain sensitive data, and the lack of security for stored kernels.

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Cloud Computing — The Future

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- In the early days of computing, most organizations had their own data centers. In the future, pretty much no one will have their own data center.
- Utilities can provide infrastructure services better than you can. Period.

Cloud Computing — Bottom Line

- As cloud computing matures and as the cost of hardware continues to drop, cloud computing will become an IT utility, used by all (like electricity as a service).

Cloud Computing — Bottom Line

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But electric utilities all provide exactly the same kind of electricity, used in exactly the same way. There is no need for local administrators to learn how to use and deploy electricity provided by, say, Puget Sound Energy *vs*. Seattle City Light.

Cloud Computing — Bottom Line

- As c ues to dro ele

And, there are limits on how much electricity an enterprise can use through its own systems. There is no way for a company to accidentally spike its annual use of electricity by, say, 10,000% through a one-day misconfiguration of some electricity-using device.

Cloud Computing — In a Research Environment

- So, what is the future of cloud computing in a biomedical research environment? Inevitable clouds? Partly cloudy forever? Something else?

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- So, what is the future of cloud computing in a biomedical research environment? Inevitable clouds? Partly cloudy forever? Something else?
- Addressing that question is the point of this meeting.
- But first, let's consider some (potentially) relevant aspects of the business model for grant-funded research …

How Do Grants Actually Work?

(short version)

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How Do Grants Work

- A PI writes a successful grant for $1,000,000 worth of research and your institution has a 65% indirect rate.
- That means the government sends your institution a check for $1,650,000, right?
- Actually, no. Instead, the government authorizes your institution to request reimbursement for up to $1,000,000 in direct research expenses and up to $650,000 in indirect expenses, provided that they (and every other expense that occurs at your institution) are properly accounted for.

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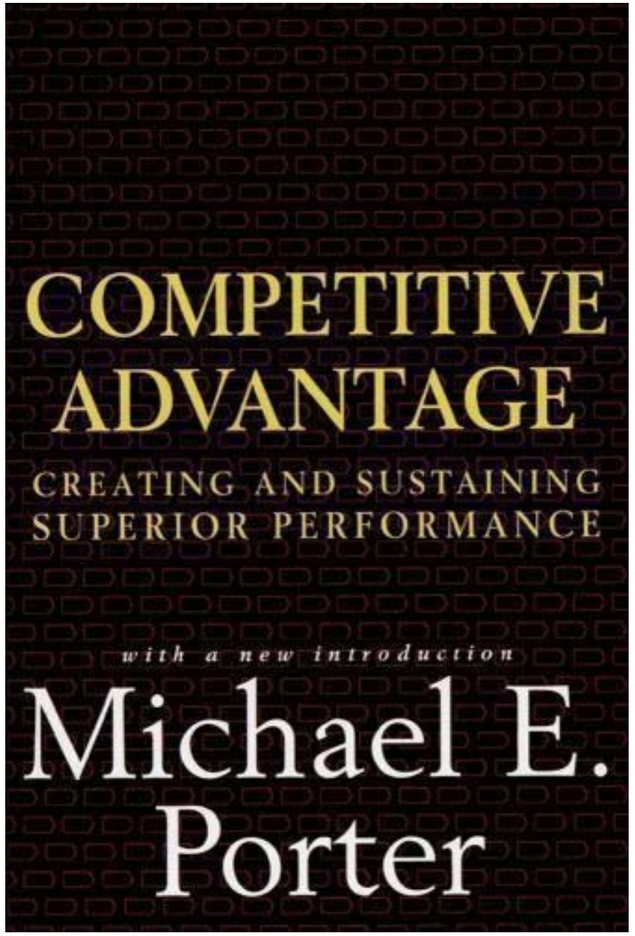
Properly accounted for means a lot of complex things, including (1) the need to distinguish between capital and non-capital expenses for the research itself, (2) the requirement that ***all*** of the institution's actual indirect costs (basic operational costs) be proportionally allocated against ***all*** of its research expenses at the same rate as used for federal grants, and (3) lots more — the topic for another talk…

Michael Porter

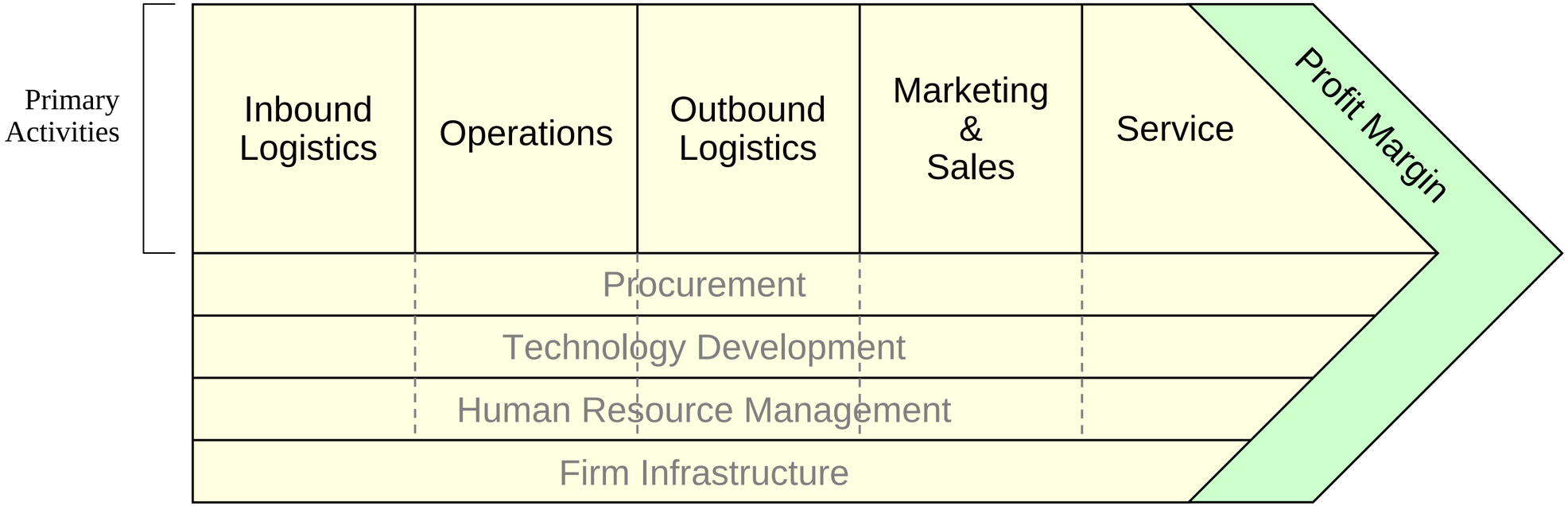
Competitive Advantage

Michael E. Porter's works on competitive advantage contain a compelling analysis of the various components of the value-adding and operational activities in a competitive enterprise.



Michael Eugene Porter is an American academic known for his theories on economics, business strategy, and social causes. He is the Bishop William Lawrence University Professor at Harvard Business School.

According to Porter, the value-adding **primary activities** of the enterprise define the enterprise. Primary activities must be managed to deliver maximum strategic competitive advantage.



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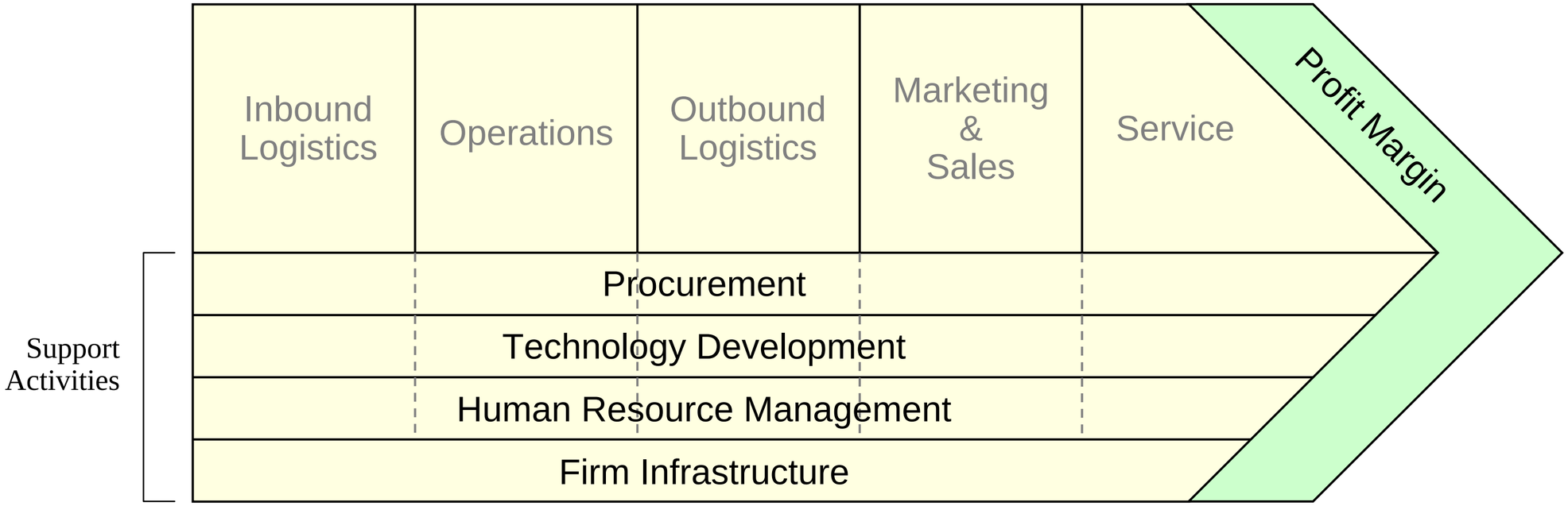
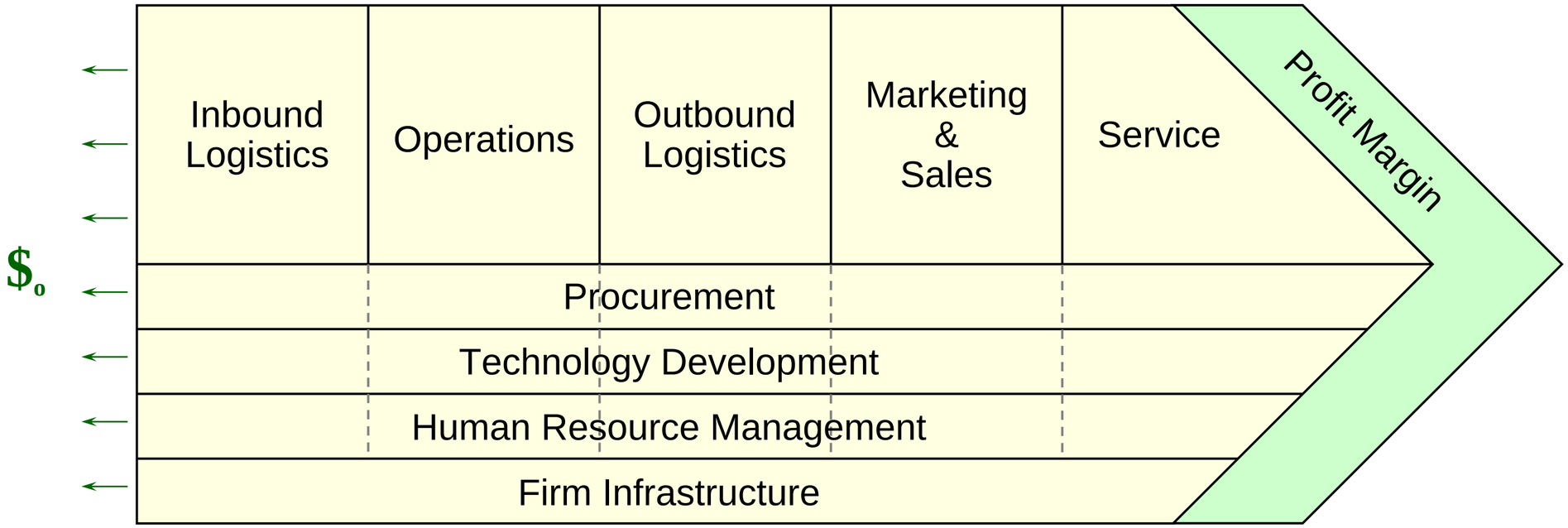
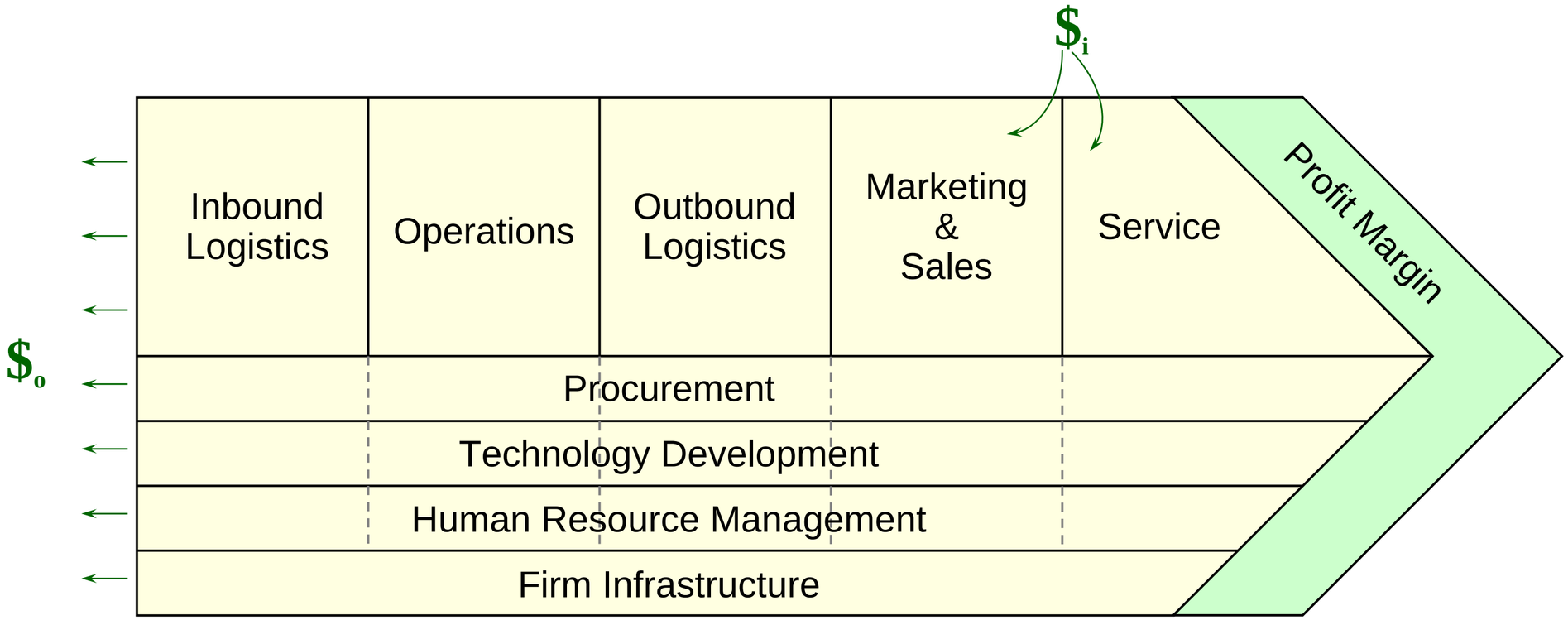


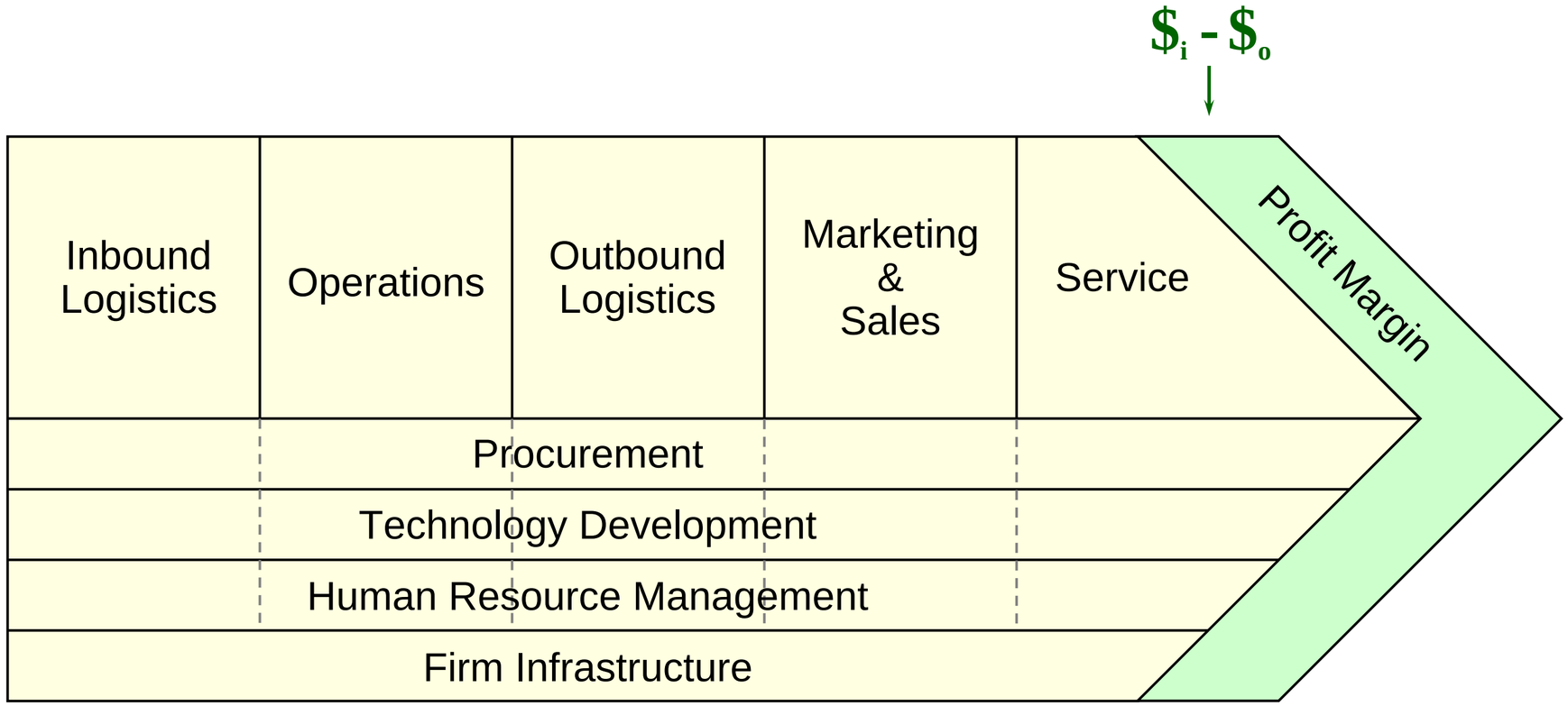
Conversely, **support activities** are necessary but not sufficient for the success of the enterprise. Support activities must be managed for maximum cost-effectiveness.



Cash outflow $\$_o$ occurs first, during the value-adding and support processes.

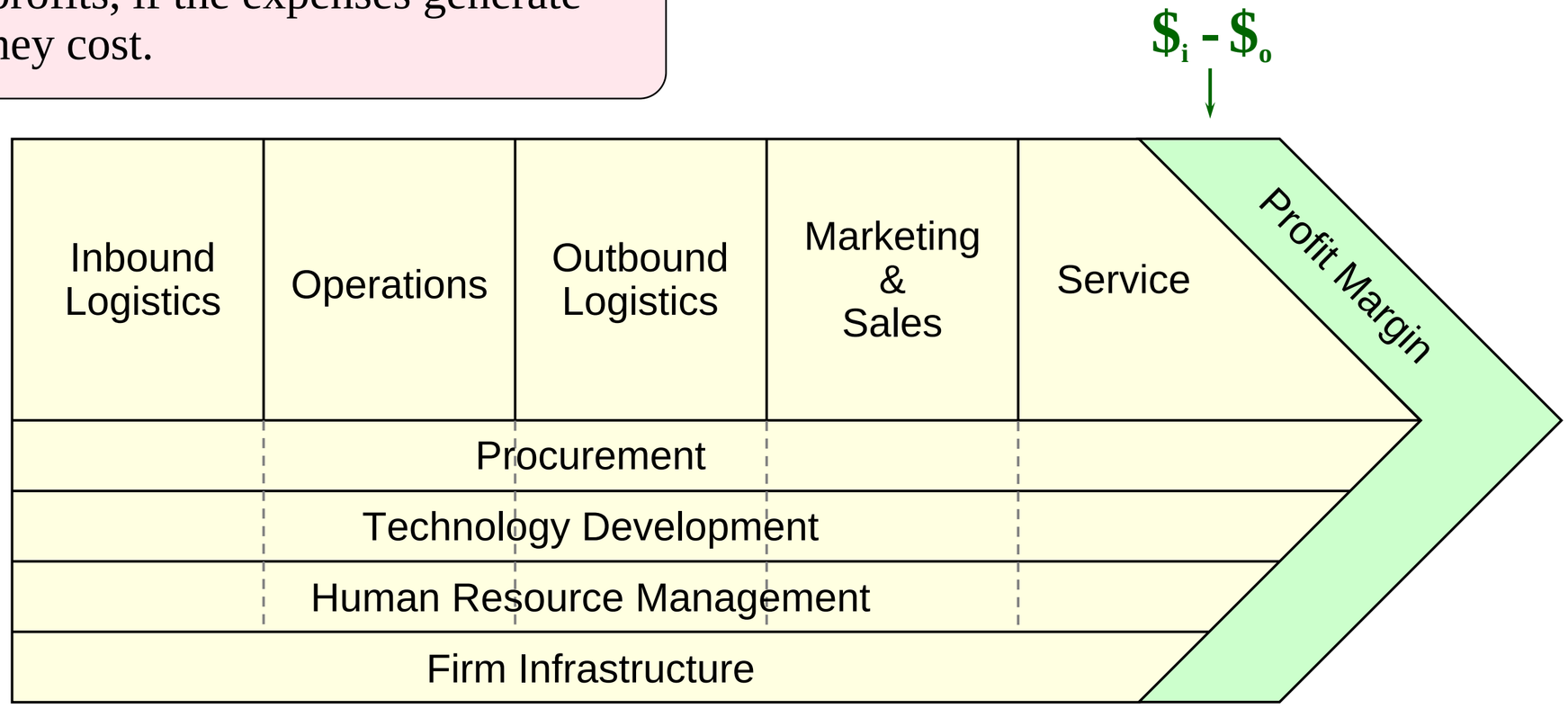


Cash outflow $\$_o$ occurs first, during the value-adding and support processes. Cash inflow $\$_i$ occurs later when the value-added products are sold to customers.



Simplistically speaking, the difference between cash inflow and outflow ($_i - $_o) provides the margin of profit. Basically, profit margin ≅ bottom line.

Some increased expenses (strategic investment) can lead to increased profits, if the expenses generate more value than they cost.



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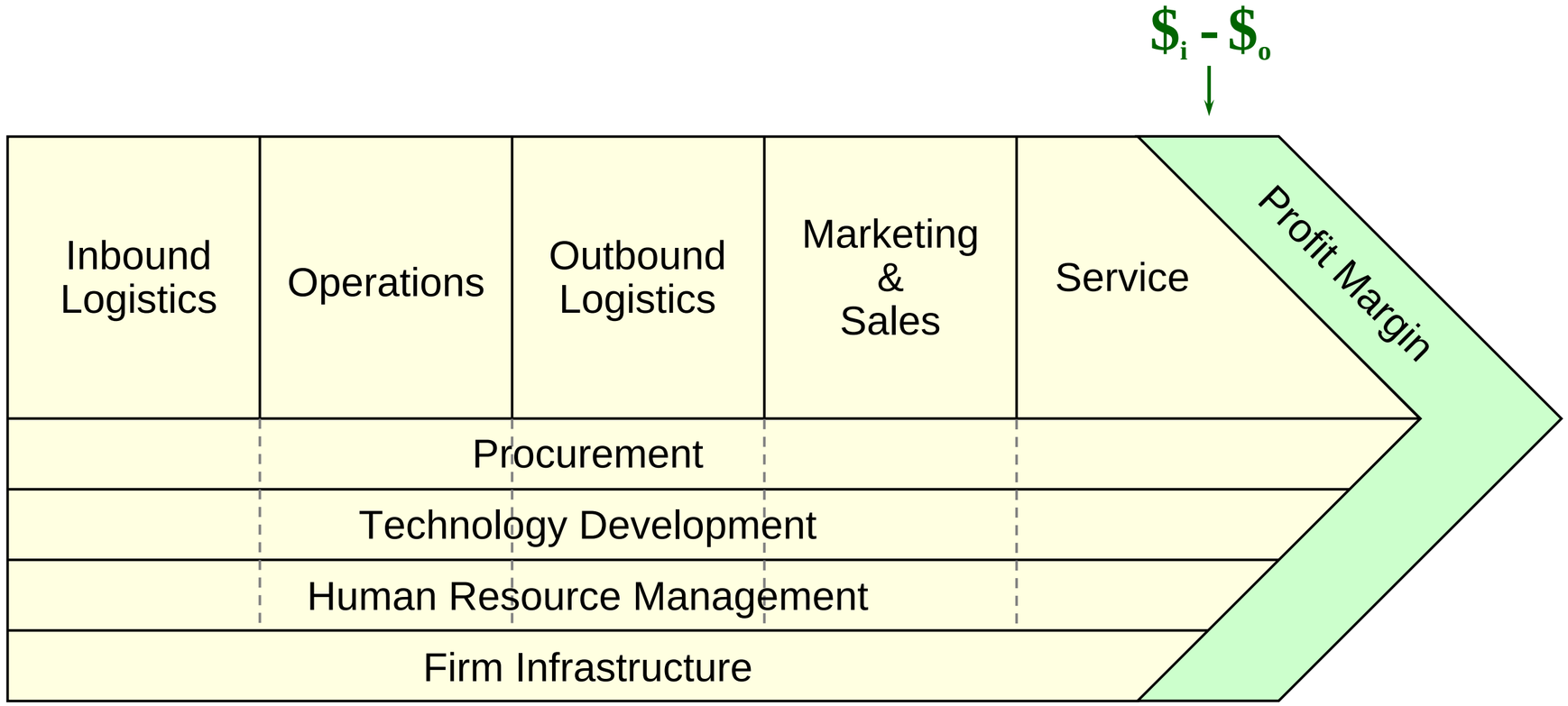
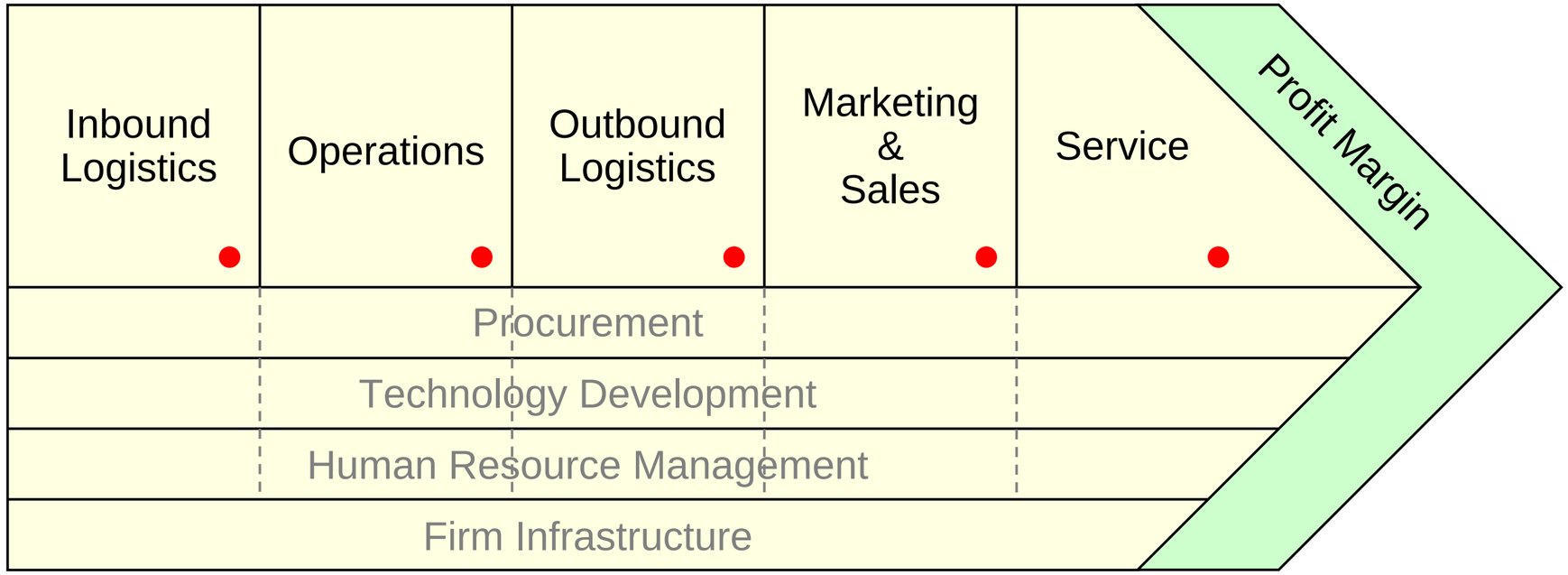


Note: Because $\$_o$ usually occurs before $\$_i$, we can judge the appropriateness of cost-incurring activities to the extent that we can measure (estimate) the effect of a particular $\$_o$ upon overall $\$_i$.

As highly plastic tools, computers can play useful roles in both the accomplishment and the management of tasks. Thus, computers have potential roles in all phases of the value chain.



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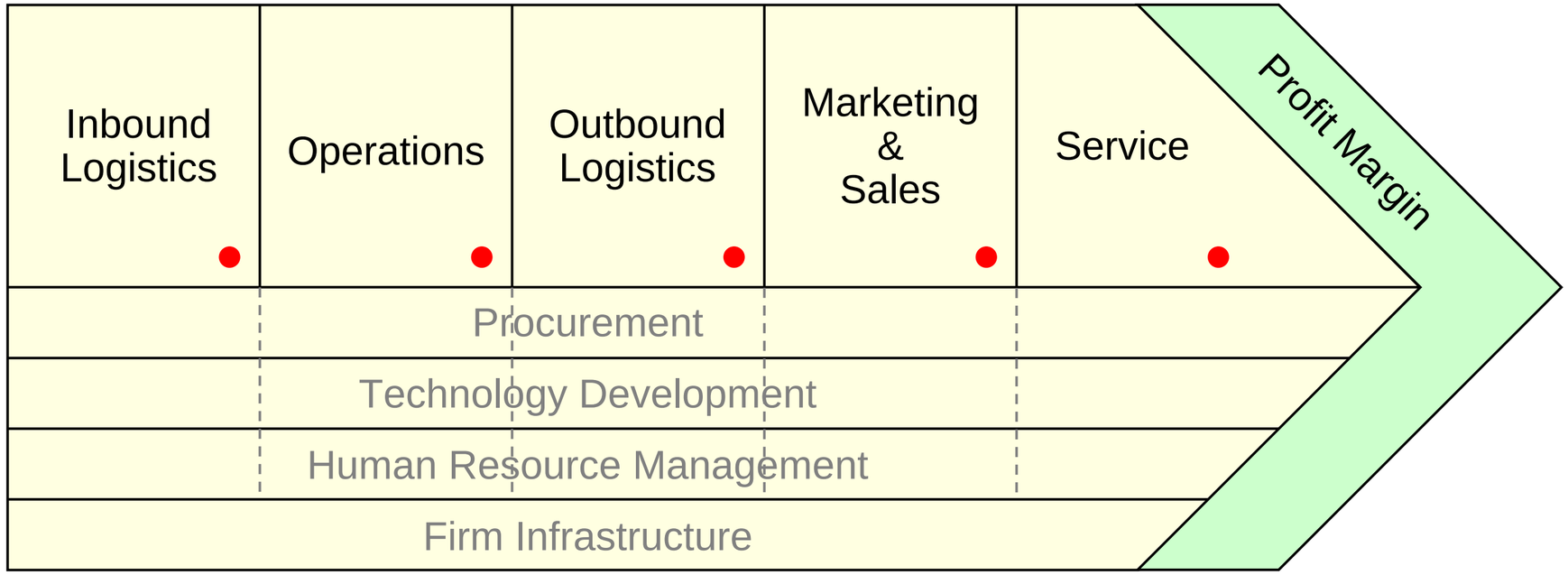
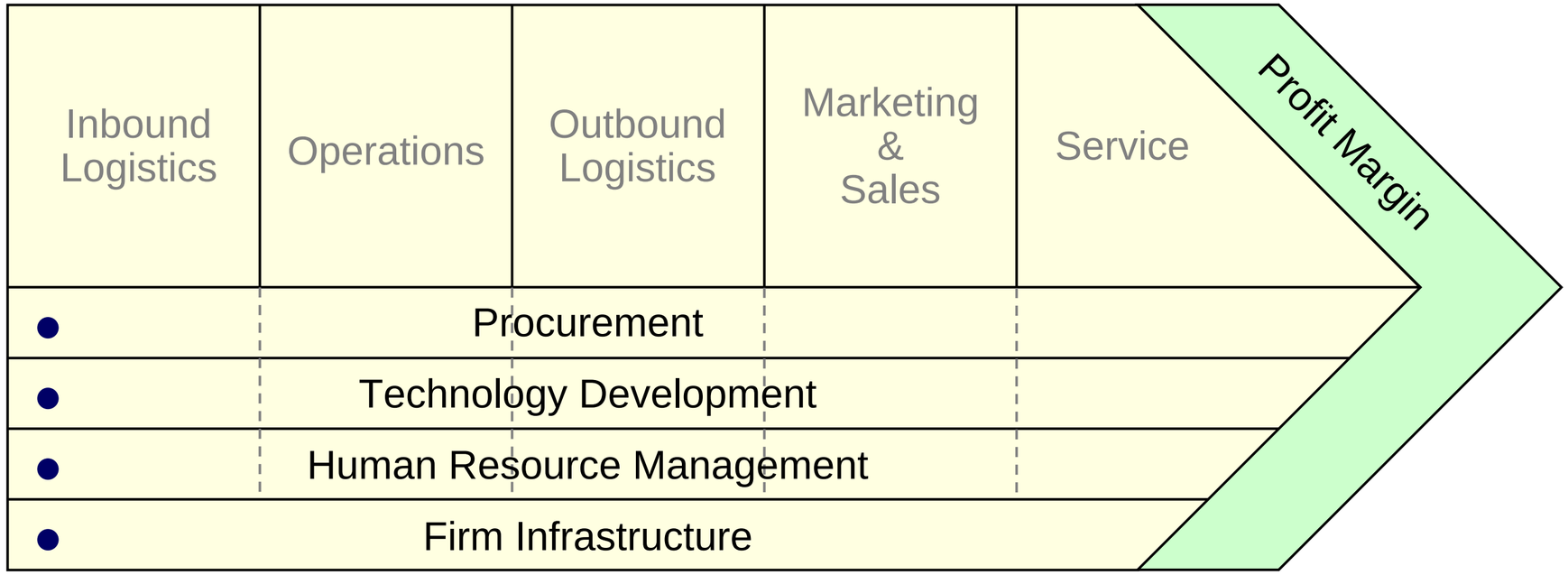
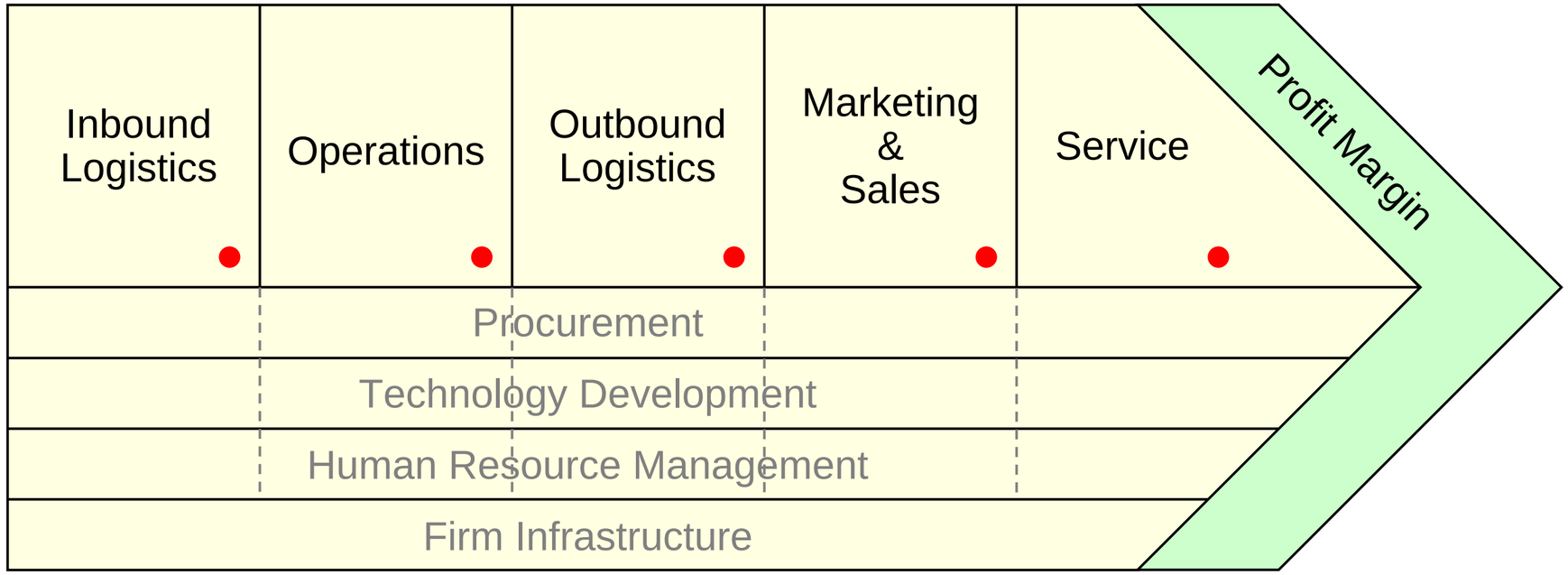


Many of the most successful companies of the last couple of decades have achieved that success through the skilled deployment of IT to great competitive advantage.



Computers can also play useful roles in many support activities. Here, IT delivers infrastructure strength and may contribute to competitive advantage through cost containment.

In the value-adding chain, IT is a strategic asset and must be managed accordingly. Investment is made to maximize strategic competitive **effectiveness**.



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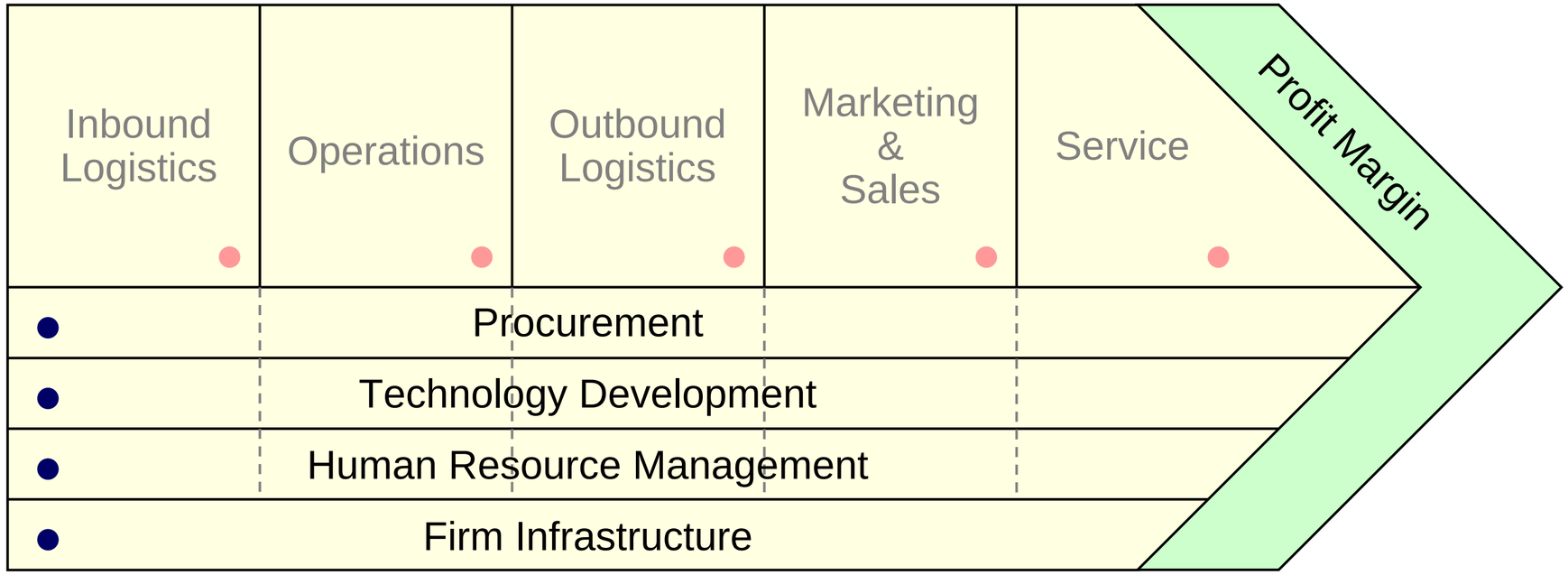
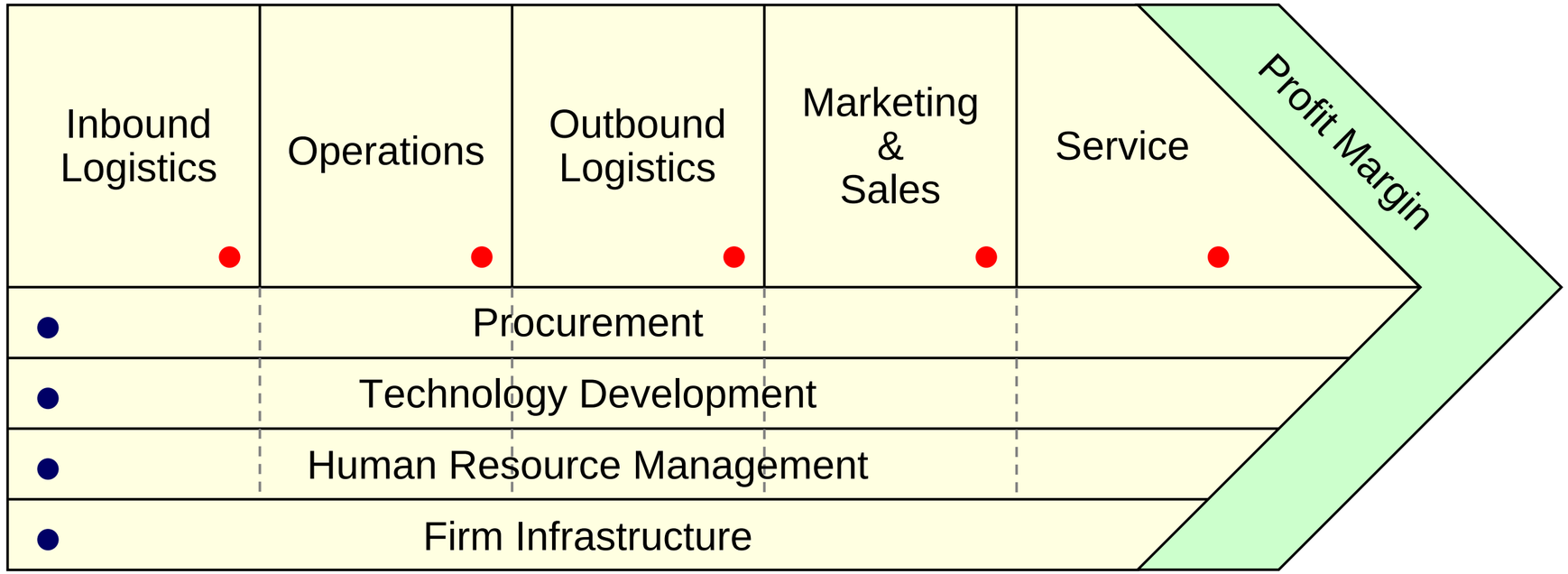


In support activities, IT is a cost-center component and must be managed accordingly. Costs must be contained and the entire operation tuned to achieve maximum operational **efficiency**.

The rapid rate of technological change adds another complexity.



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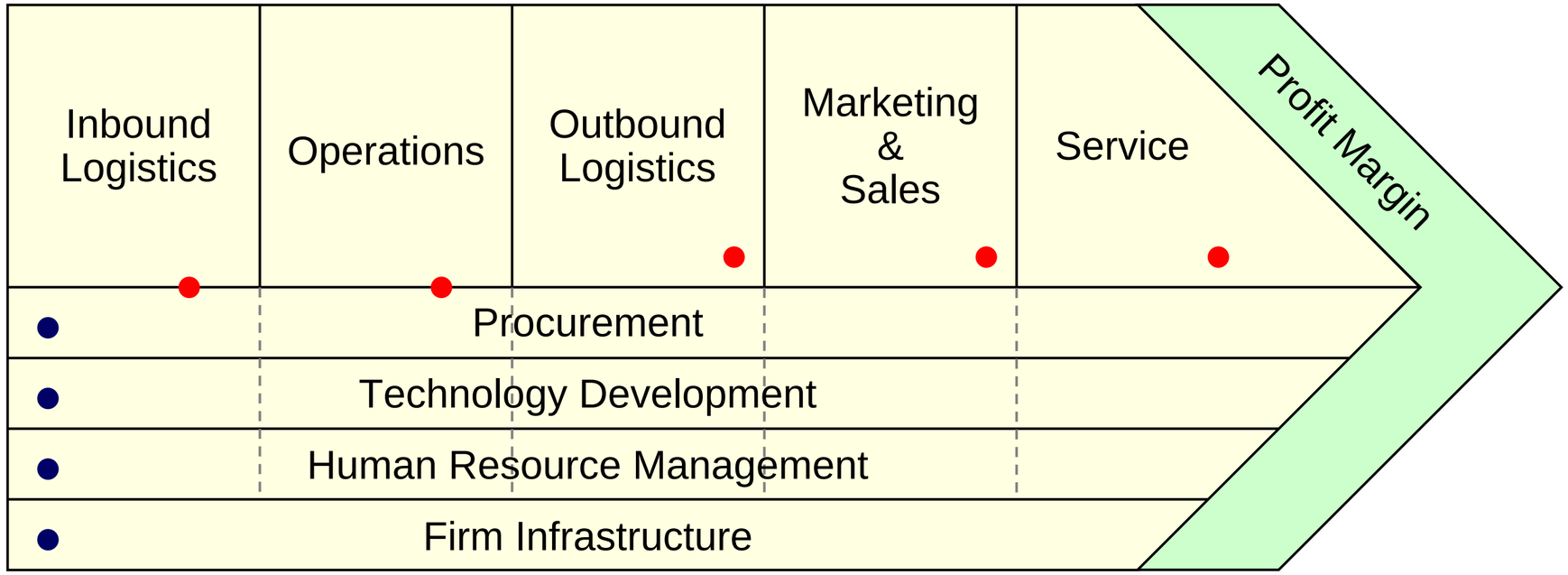

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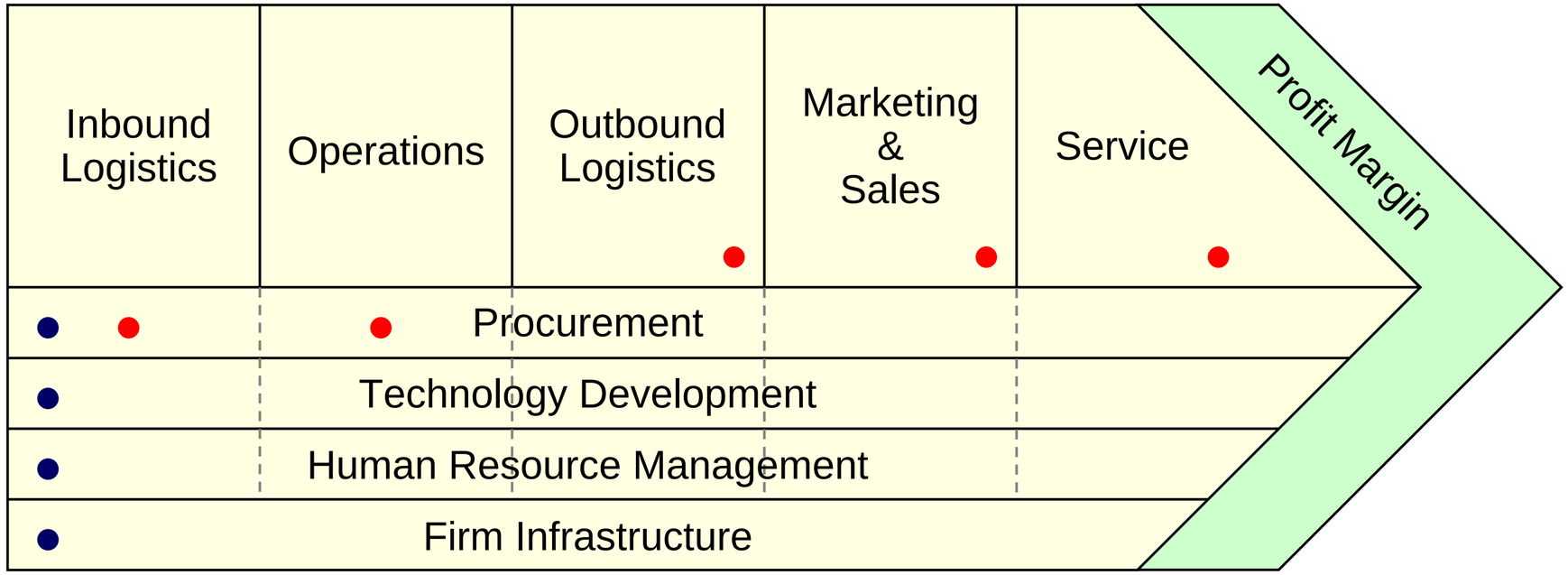

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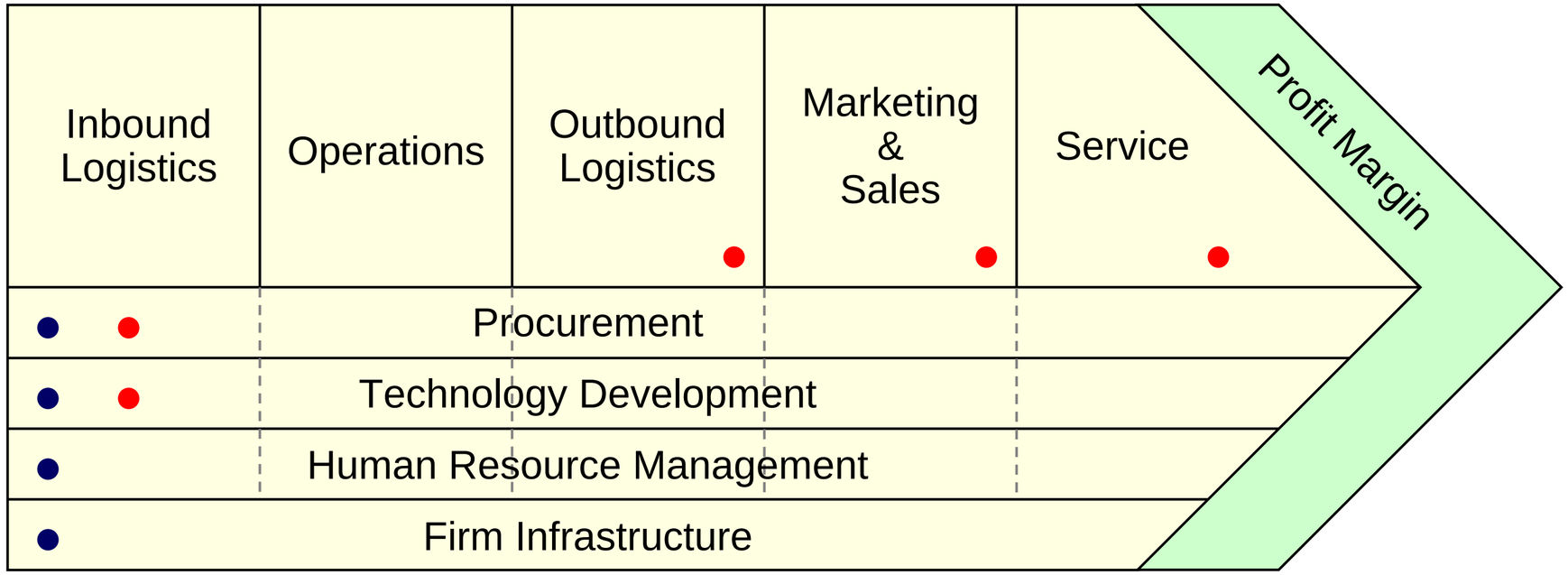

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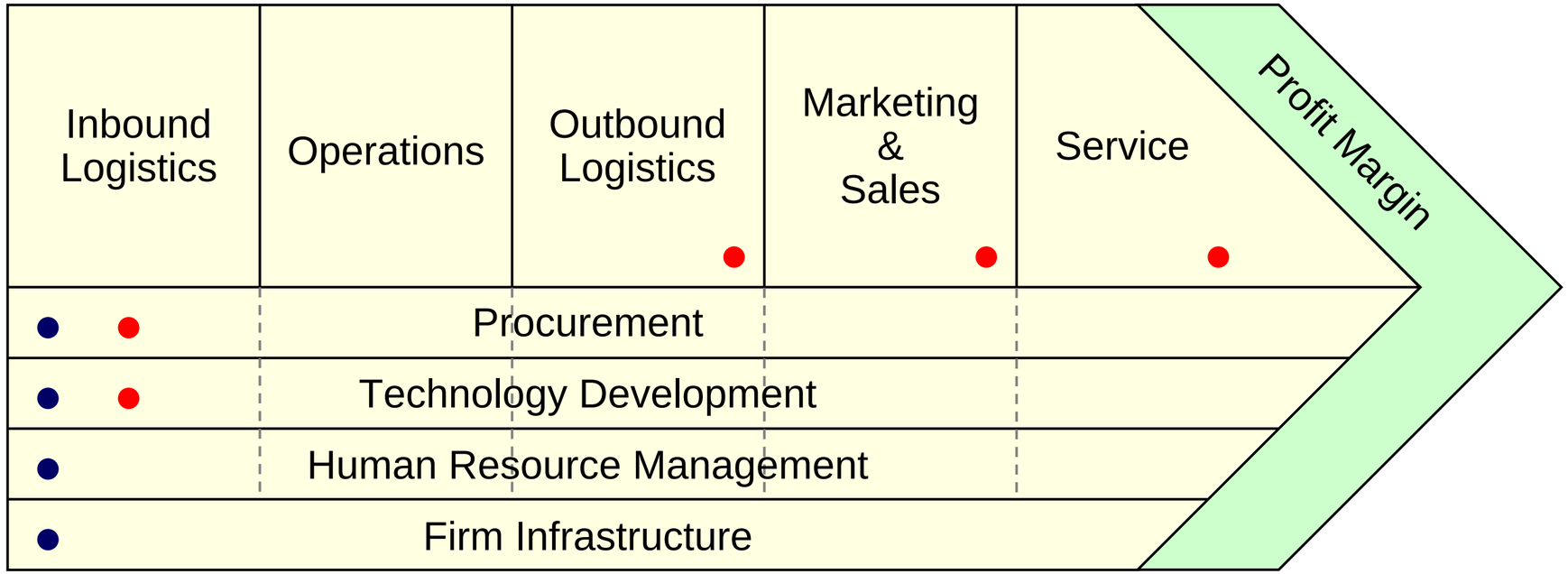

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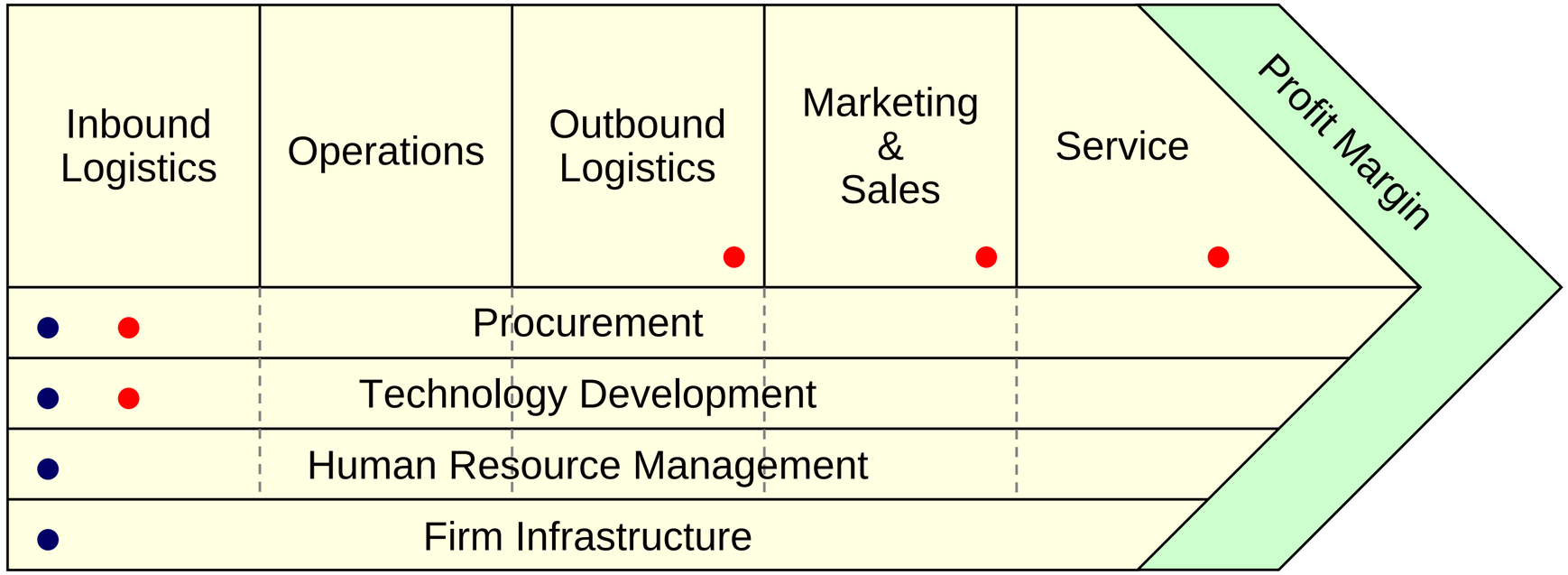
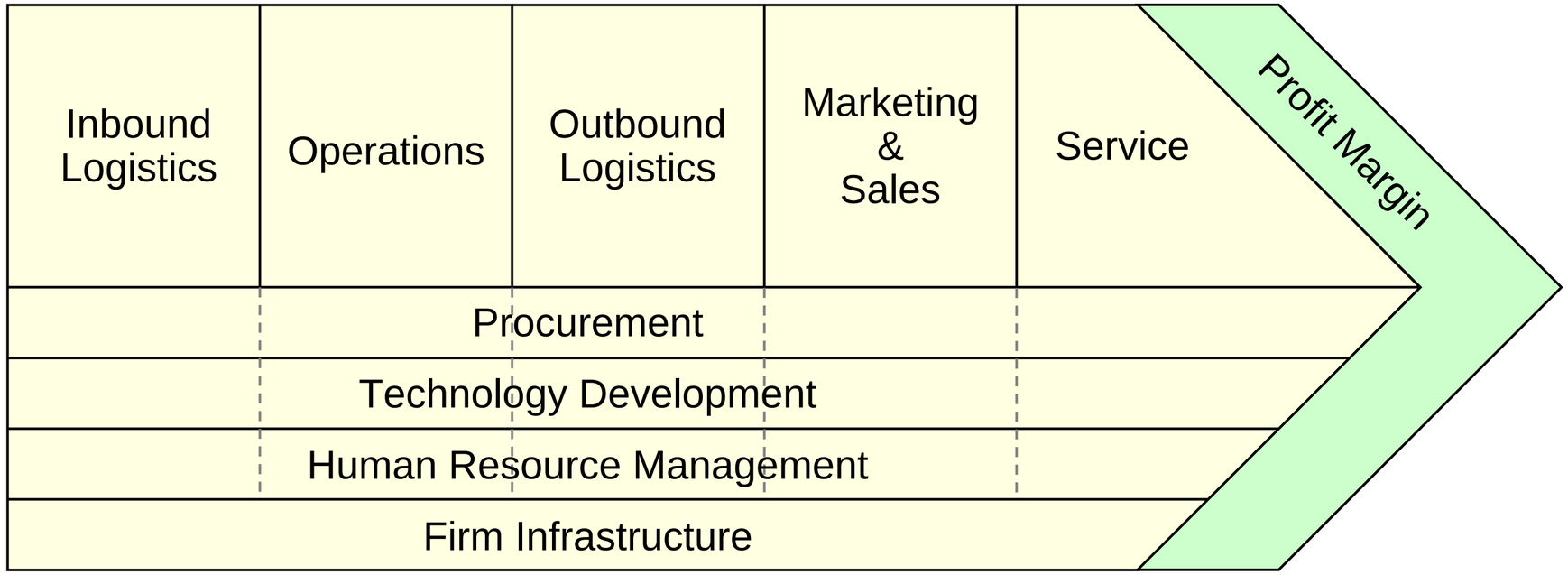


In a grant-funded environment, the primary value-adding activities are funded with **direct** dollars, whereas the support activities are funded with **indirect** dollars.

Despite increased recognition of its importance, investment in IT to support public-sector, grant-funded research historically has been slower than in the private sector. Why?



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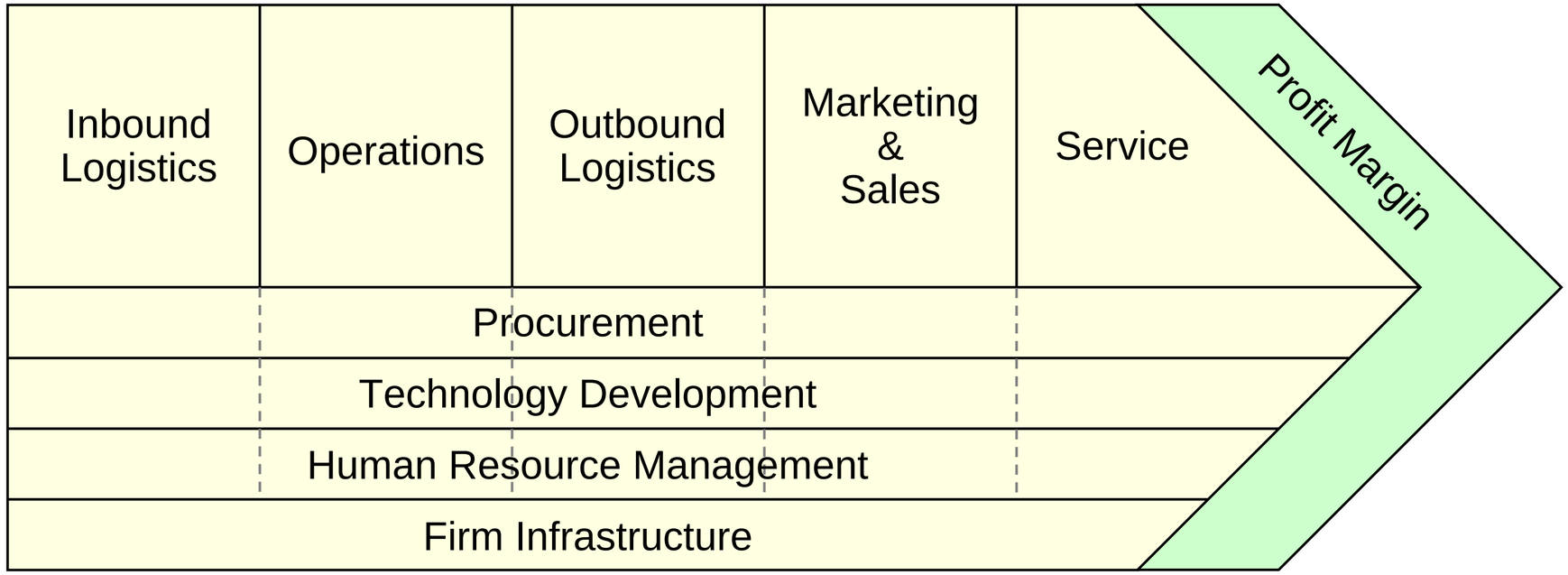
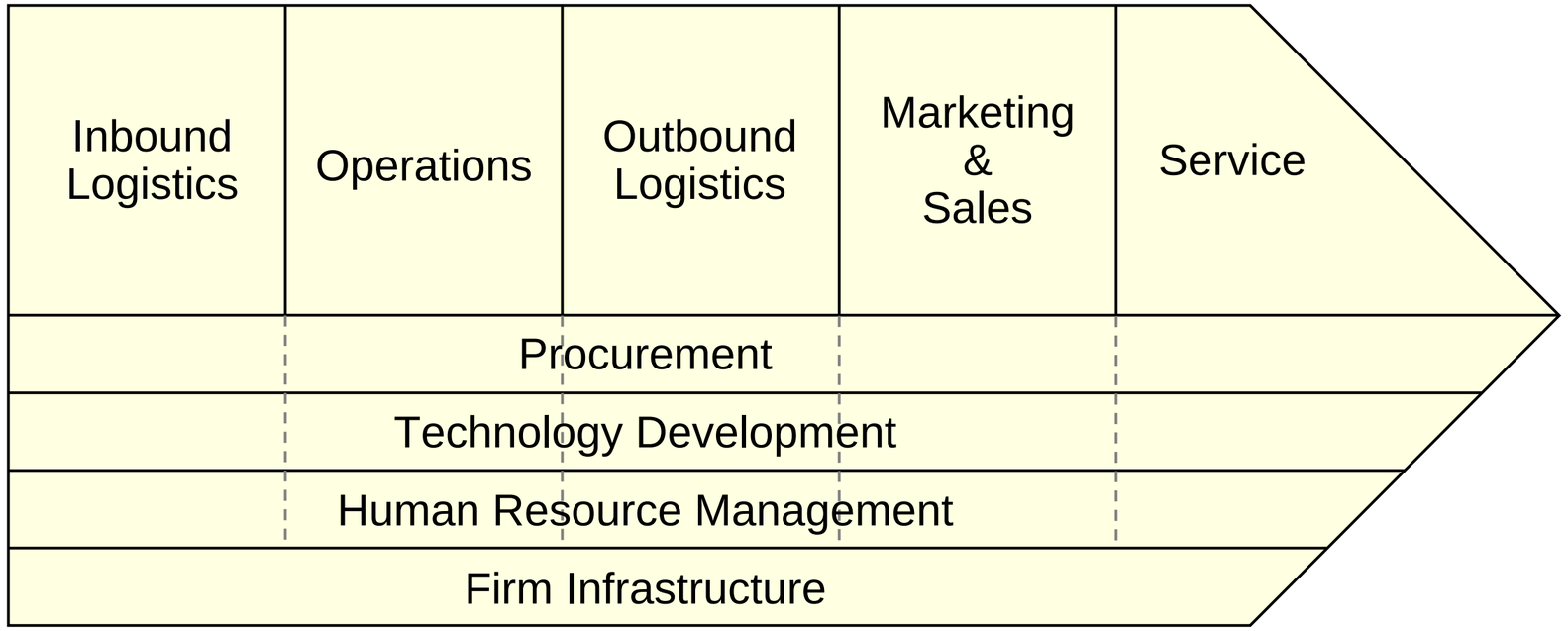


Other factors complicate the daily management of and the long-term planning for IT operations in a biomedical research organization.

First, the reimbursement model for grant funding rules out the possible existence of a profit margin, thereby eliminating both the justification for strategic investment and its source of funds.



Second, even at a generic level, the value-adding activities for research are different from those of commerce.

Inbound Logistics	Operations	Outbound Logistics	Marketing & Sales	Service
Grant Writing	Inbound Logistics	Research Operations	Outbound Logistics	Publication

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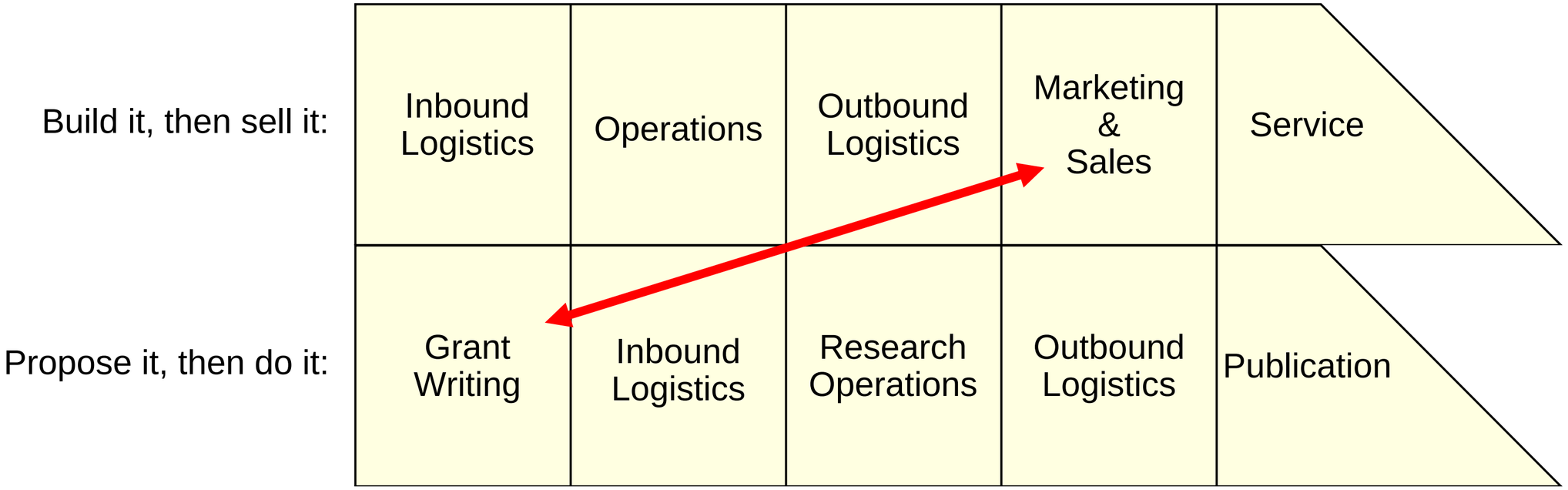
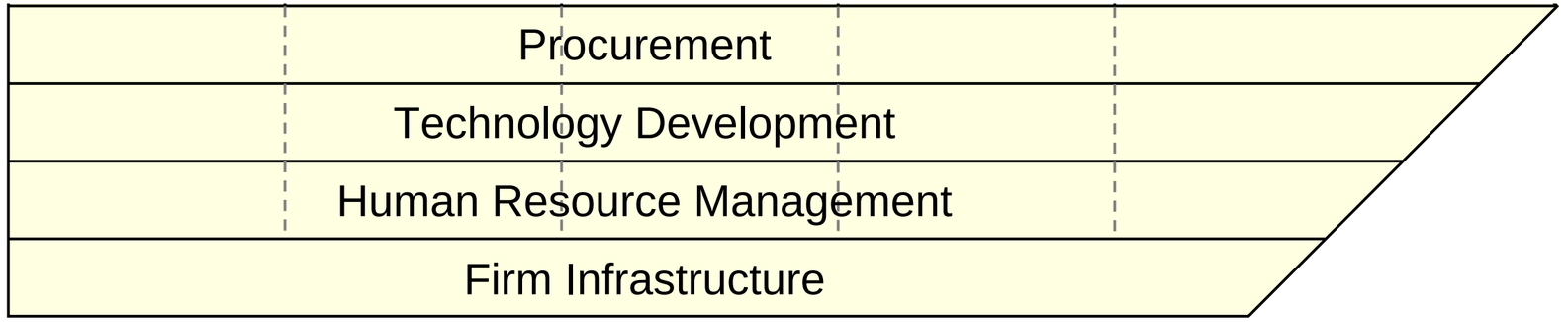


Not only are the categories somewhat different, but there is a significant reversal in time sequence of some components.

Although some differences exist in the support activities, these are not as significant as those in the primary activities.



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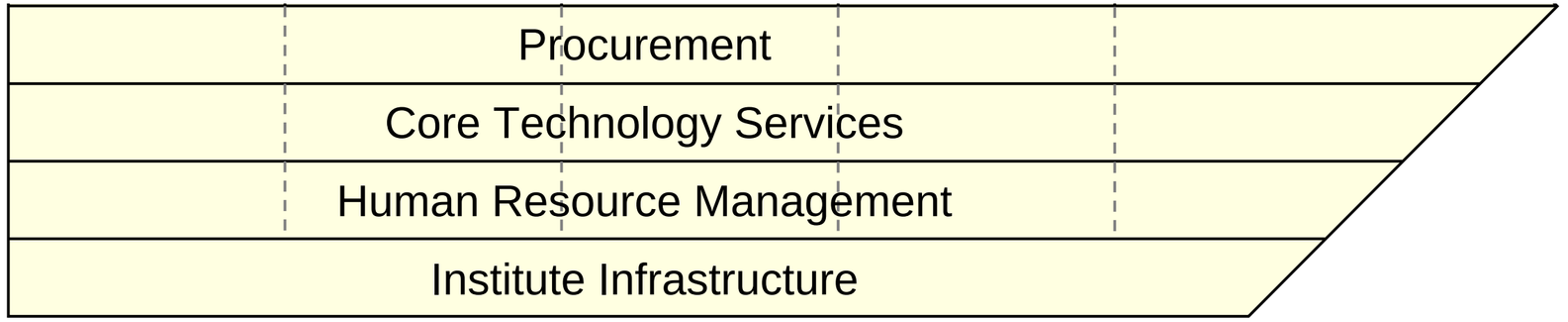
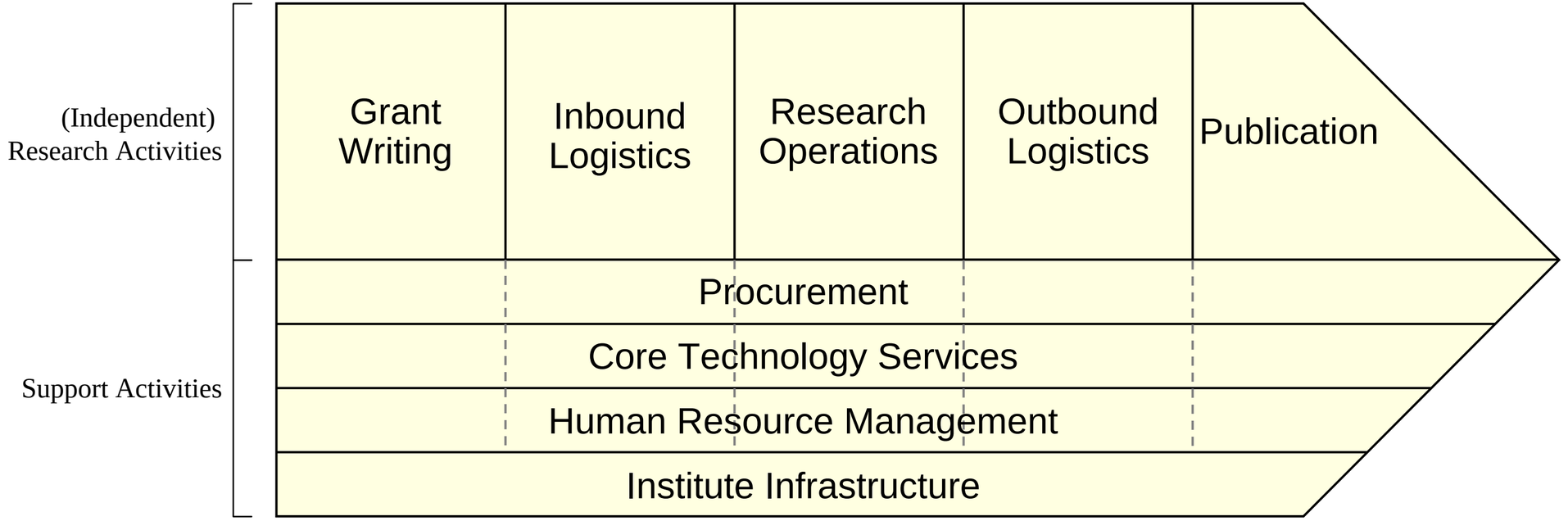


Combining these adjustments we get the following "Porter diagram" for research.



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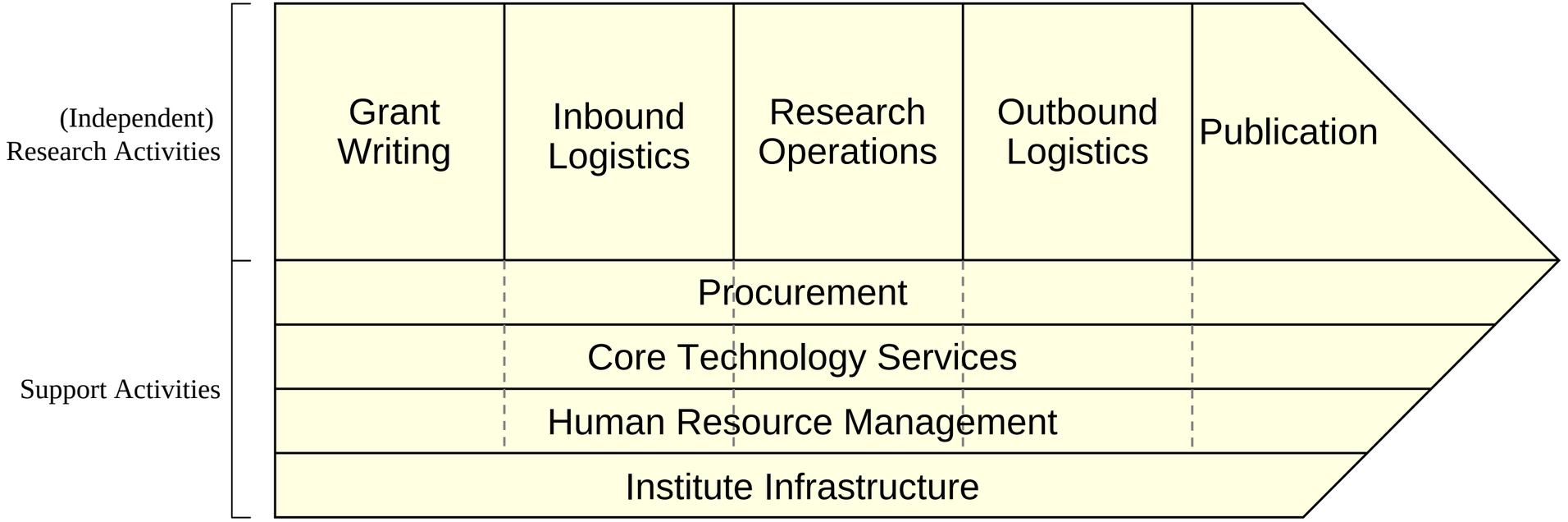
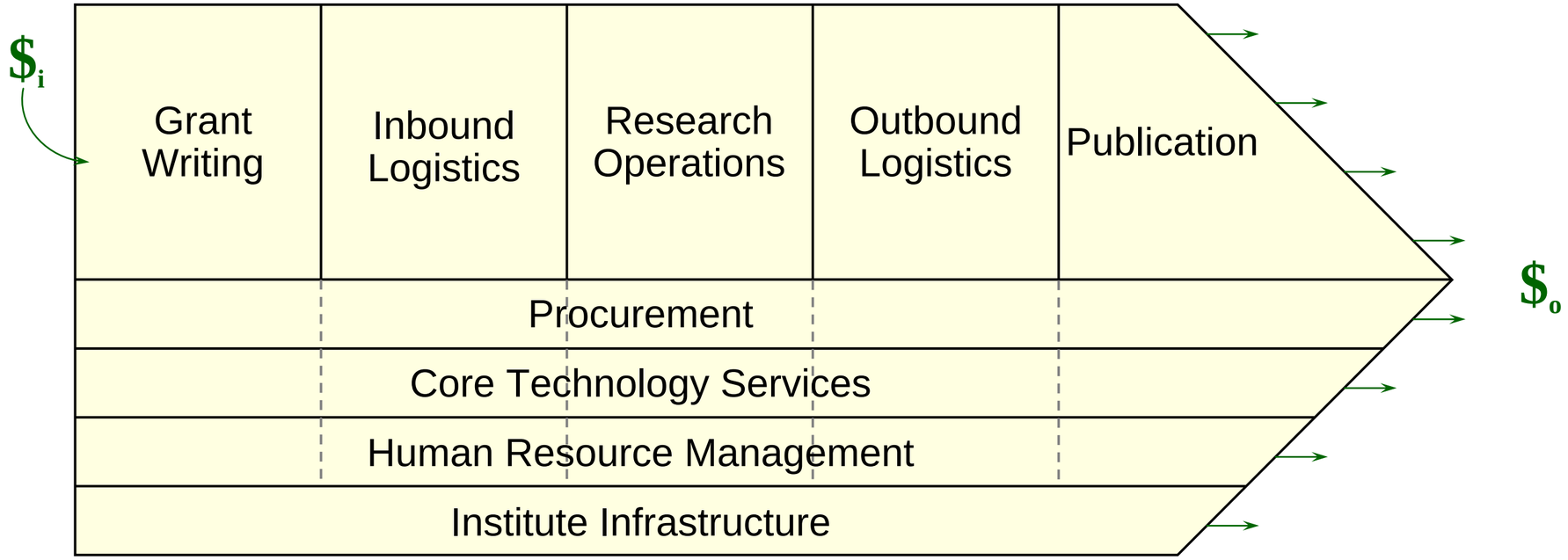


Now we can consider some other complicating factors…

Cash flow is backwards, in that “income” precedes expenses. Furthermore, “income” is really just authorization to request reimbursement for appropriate expenses.



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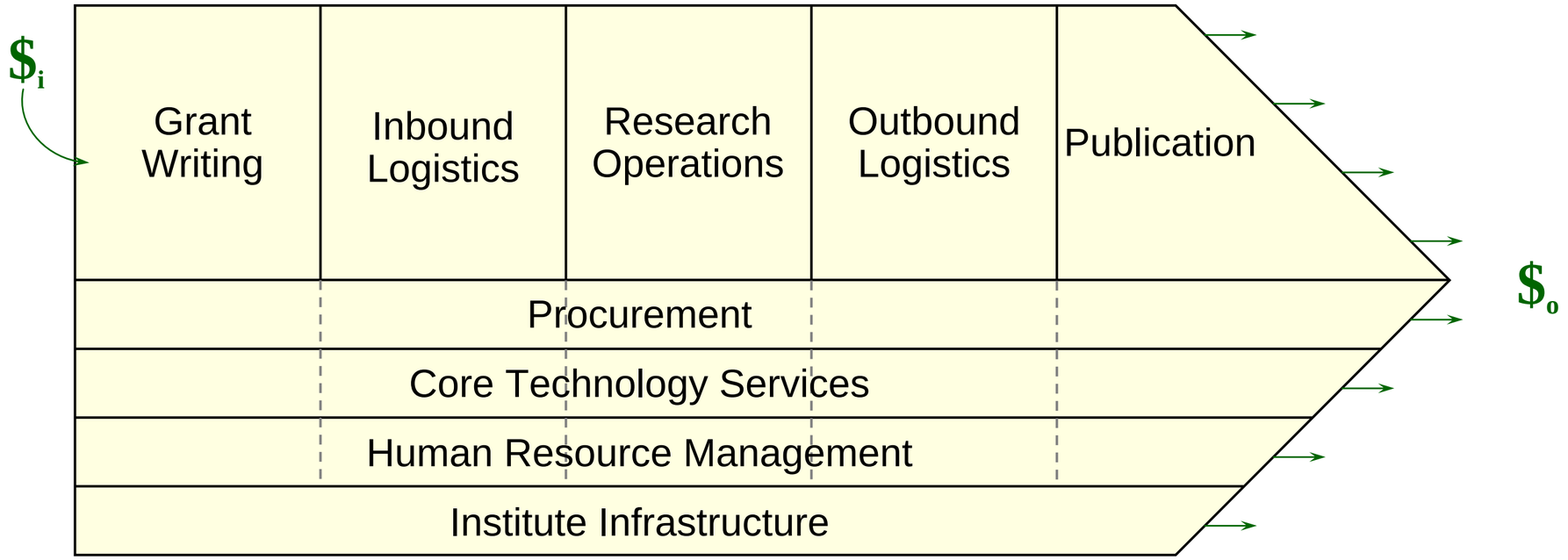
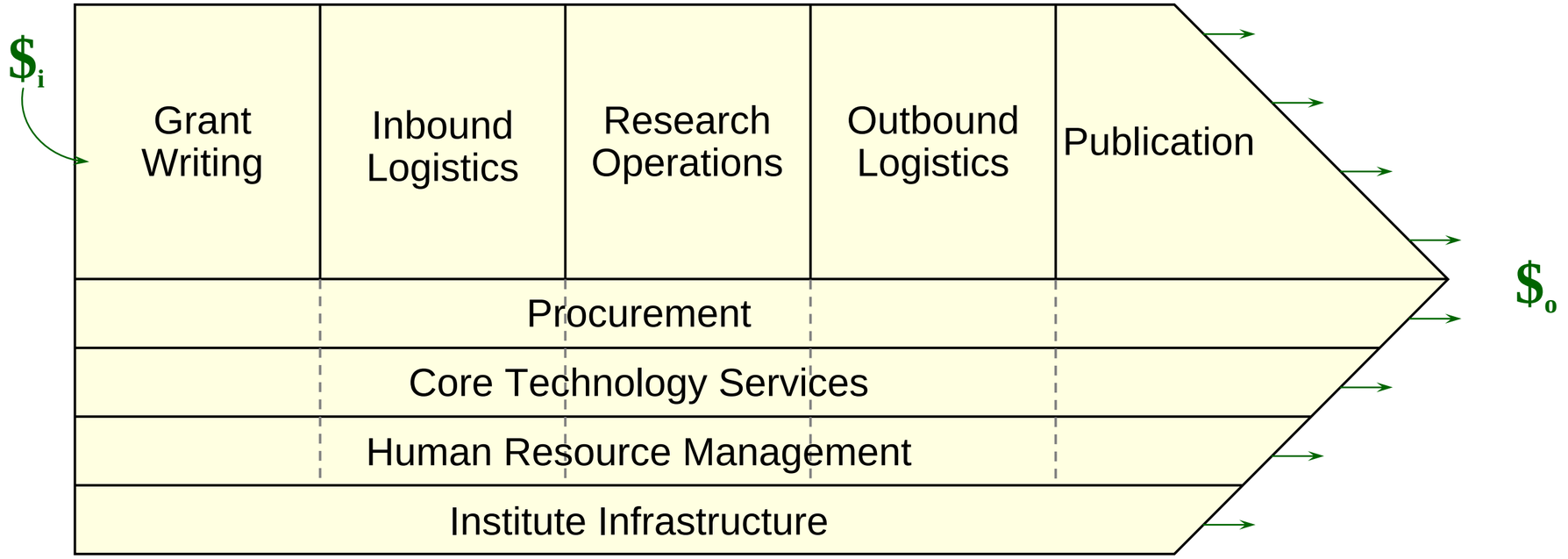
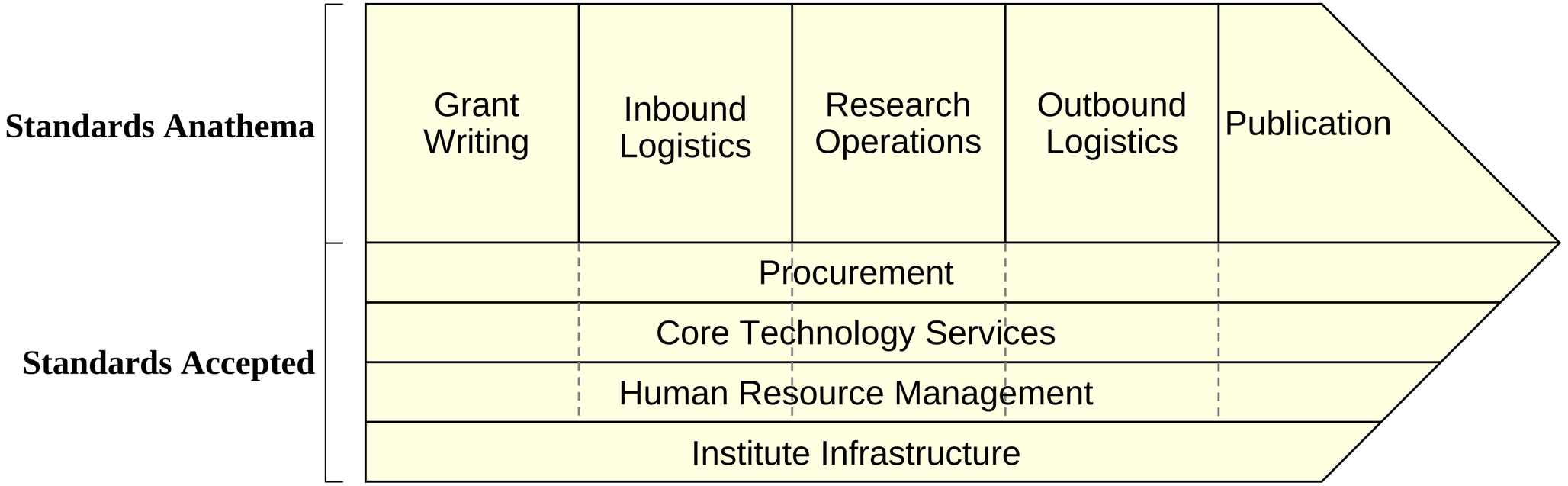


Because $\$_i$ is capped as a reimbursement for an approved subset of $\$_o$, $\$_i$, must always be less than or at best equal to $\$_o$. This means there can never be a real profit margin.

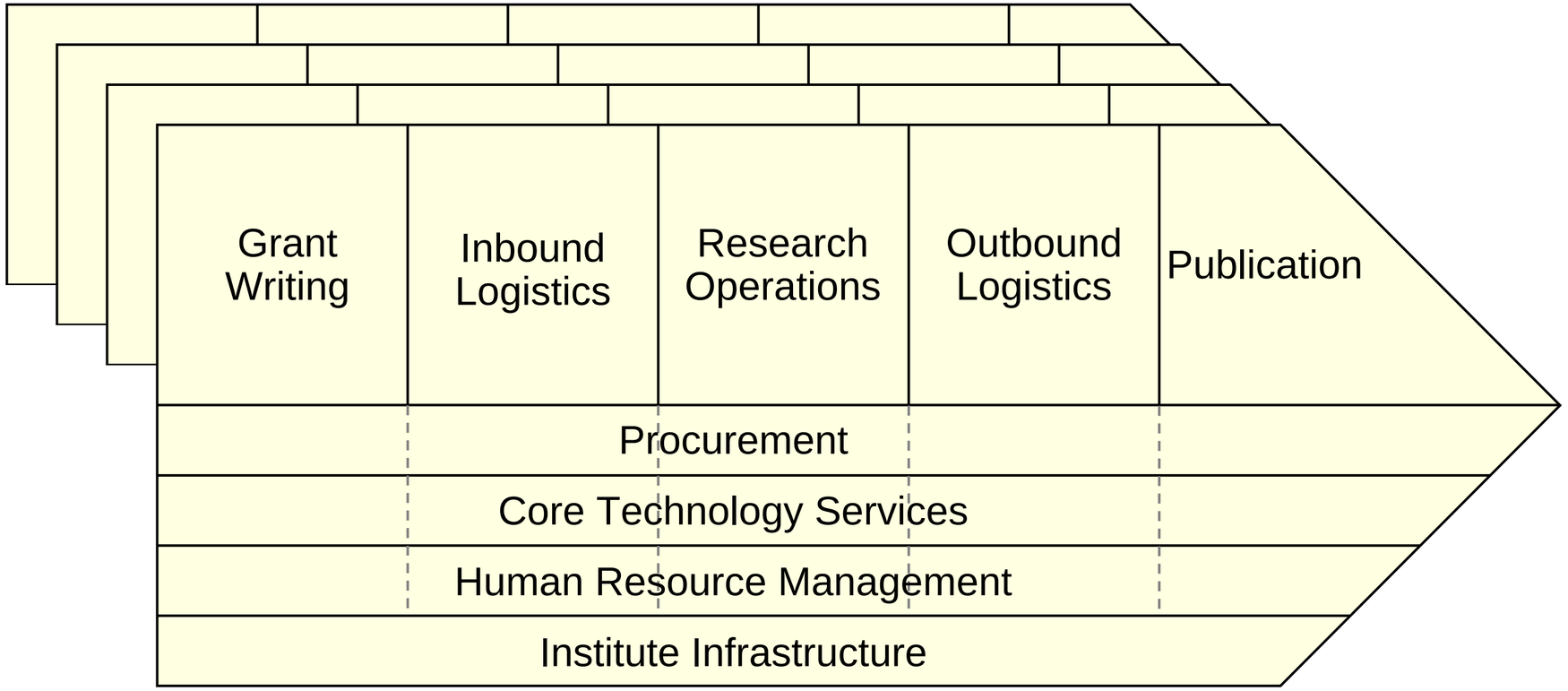
Without a profit margin, true strategic investment in IT is difficult, if not impossible. Furthermore, “income” is really just authorization to request reimbursement for appropriate expenses.



Thus, compared with private-sector enterprises, strategic IT investment in grant-funded research organizations is often trivial and ineffective.



The sociology of public-funded research activities resists efficiencies in the value-adding chain. Much of this resistance is **legitimate**.



In a grant-funded research organization, there are multiple value-adding chains, one for each independently funded research activity.

Business Model

- The Porter value-chain analysis shows that the funding model, and the value-adding process of grant-funded research is fundamentally different from that of businesses that sell goods or services to consumers.
- Measuring ROI is metaphorical (at best).
- No common measurement for success – i.e., no bottom line.

How Different is Research IT?

A Few Dialogues

Vendor Dialogue, I

Ven: Do you have a lot of databases at your institution that can't talk to each other?

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Ven: (after flipping through his script and failing to find a canned response to my "no" answer) Why not?

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Me: Well, one of them is a catalogue of all cases of human cancer occurring in the residents of 13 counties in northwest Washington State and another is a collection of genetic-map data in fruit flies. If they could talk to each other, what would they say?

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Me: Well, then it won't work for us.

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Me: Our funding model does not allow us to generate a positive bottom line. Any money spent on software is money not available to support the Center's mission, which includes saving the lives of kids with leukemia. One BMT anti-leukemia treatment costs $250,000. If your product costs $250,000 then that's one kid who doesn't get a BMT. So, how good is your software? How many kids should we let die so that we can have access to your product? Two dead kids? Five?

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Ven: That's harsh.

Me: Yes, but that's the reality of our financial environment…

Understanding Research Operational Practices

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- Projects deal with the unknown, cannot be standards driven
- Research is intensely opportunistic: new insights may require immediate redirection of project plans and design
- Pan-enterprise collaboration is commonplace. Imagine supporting cloud-computing research, if the main researchers at Amazon and Google and Microsoft spent more time talking with each other than with their own corporate management.

Understanding Research Cultural Norms

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- Criticism is a primary form of discourse
- ***I'm from admin and I'm here to help*** often provokes a fear response, followed by a major immune reaction.

Understanding Research IT Operations

Delivering IT to Meet Research Needs

- We have no external customers for our computer services, we only have external “customers” for our publically shared (published) findings.

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- Improvements in our IT environment cannot produce any immediate, real-time effects on our revenue streams.

Conclusions

Going Forward

Conclusion:

- How well will (does) cloud computing work in a grant-funded research environment?
  - What advantages does it bring?
  - What known challenges and limits does it encounter?
  - What new challenges and limits will it encounter?
- Let’s find out!

END

Robert J. Robbins

RJR8222@gmail.com

(http://www.rj-robbins.com/slides/RJR-PCNF-2018.pdf)