# An agile pathway towards carbon-aware clouds

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**Disclaimer: an *opinionated* talk with systems implications — let's discuss!**

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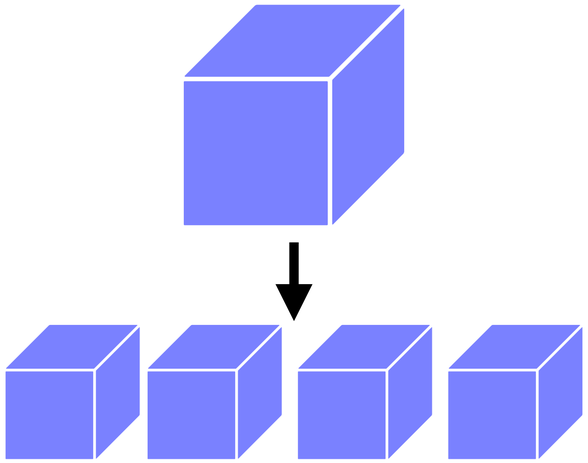

**Applications span**
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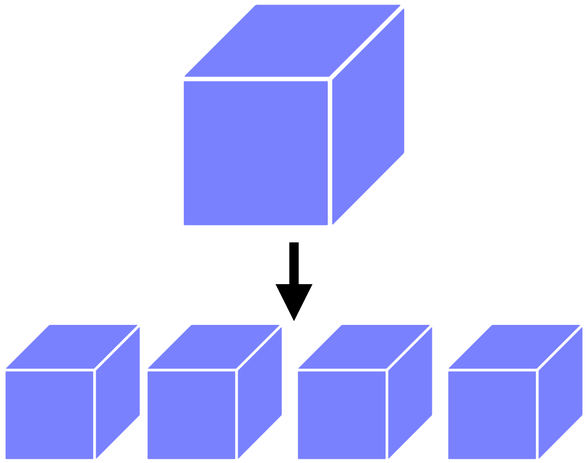

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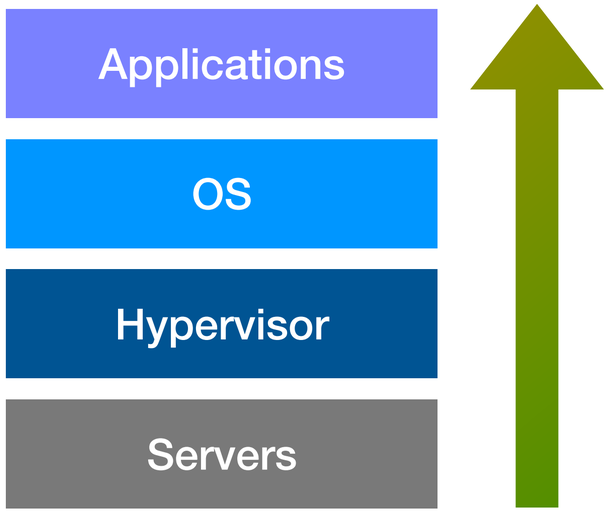


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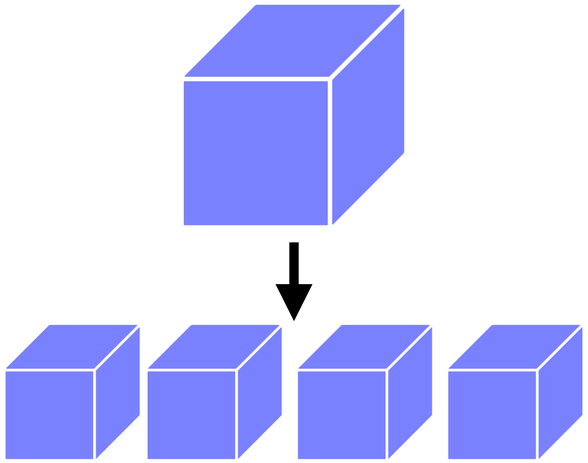

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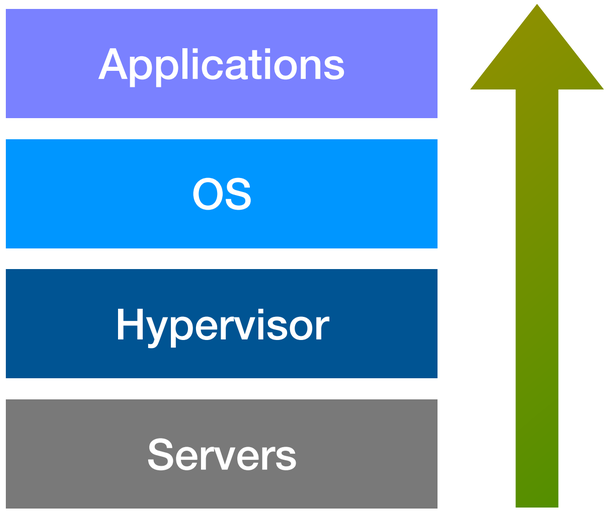


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**Clearly, a very challenging problem!**

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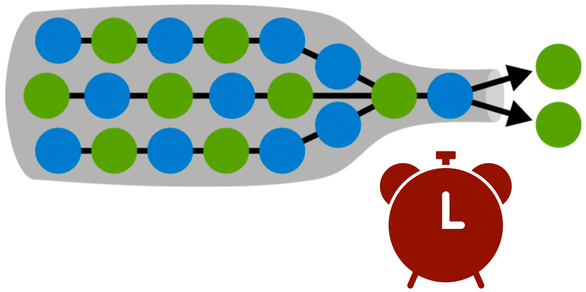

**Developer time is a *business bottleneck***

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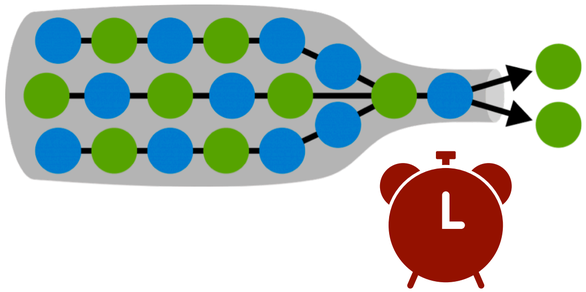

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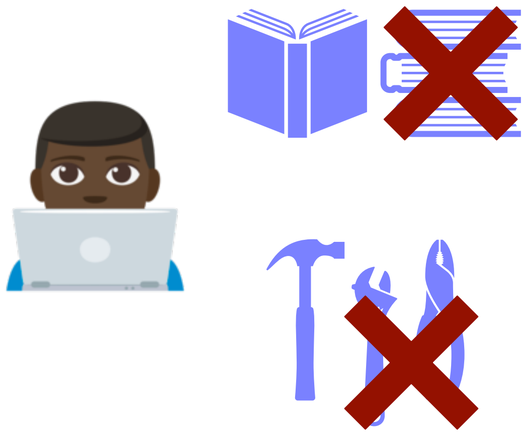

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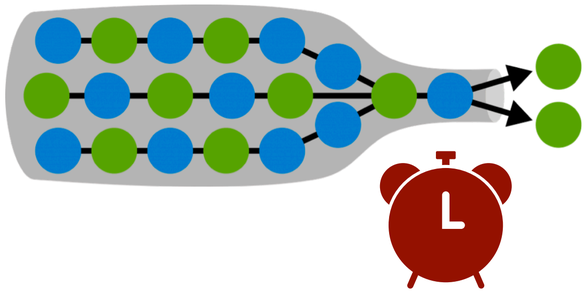

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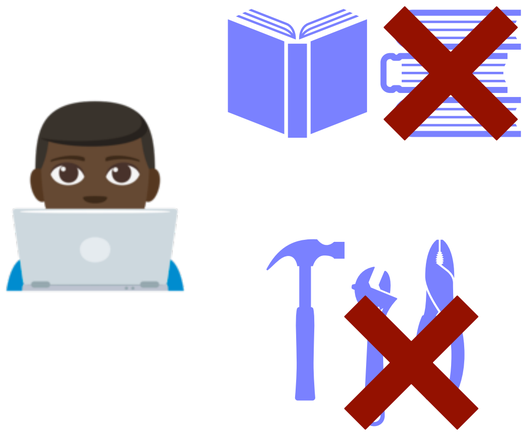

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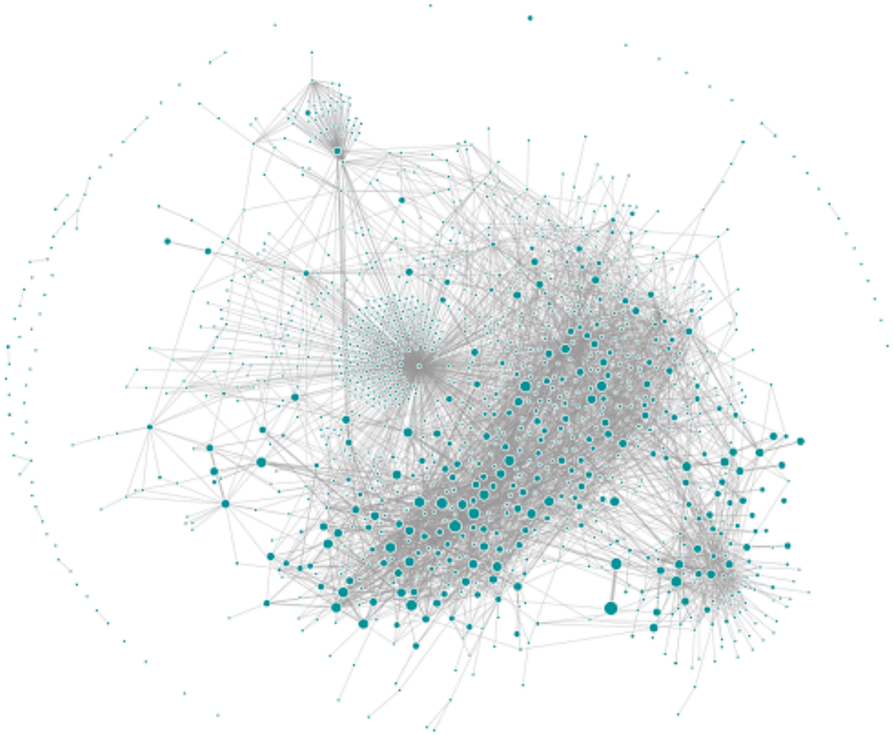

***Rewriting apps* may be *infeasible***

Uber's ~2,200 microservices visualized by Jaeger (2018)

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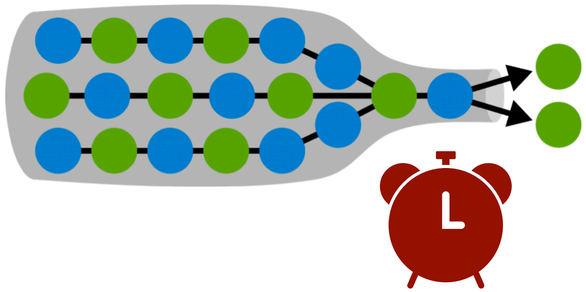

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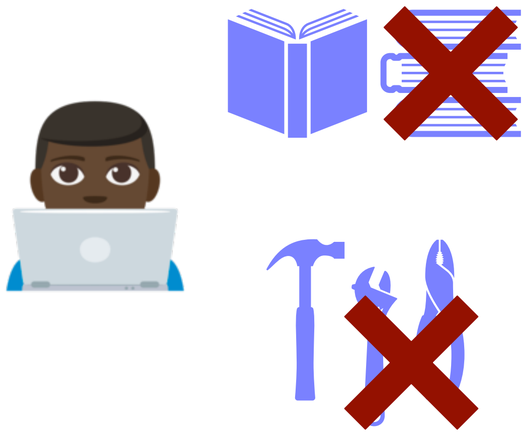

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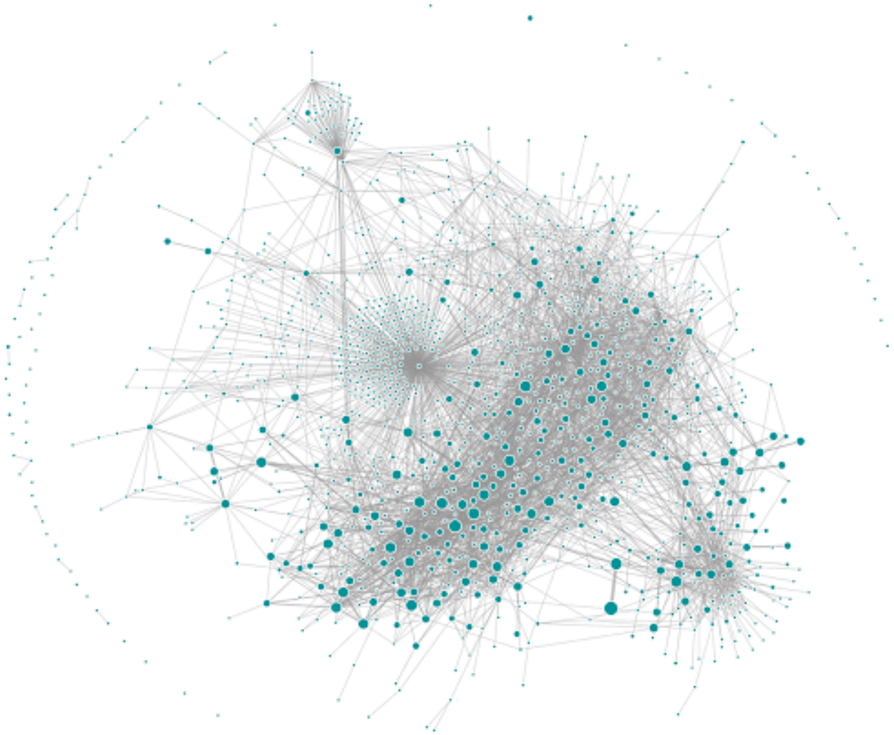

***Rewriting apps* may be *infeasible***

**Who can make an impactful and timely difference? How can we help them?**

Uber's ~2,200 microservices visualized by Jaeger (2018)

# A closer look at large-scale application teams


*simplified model

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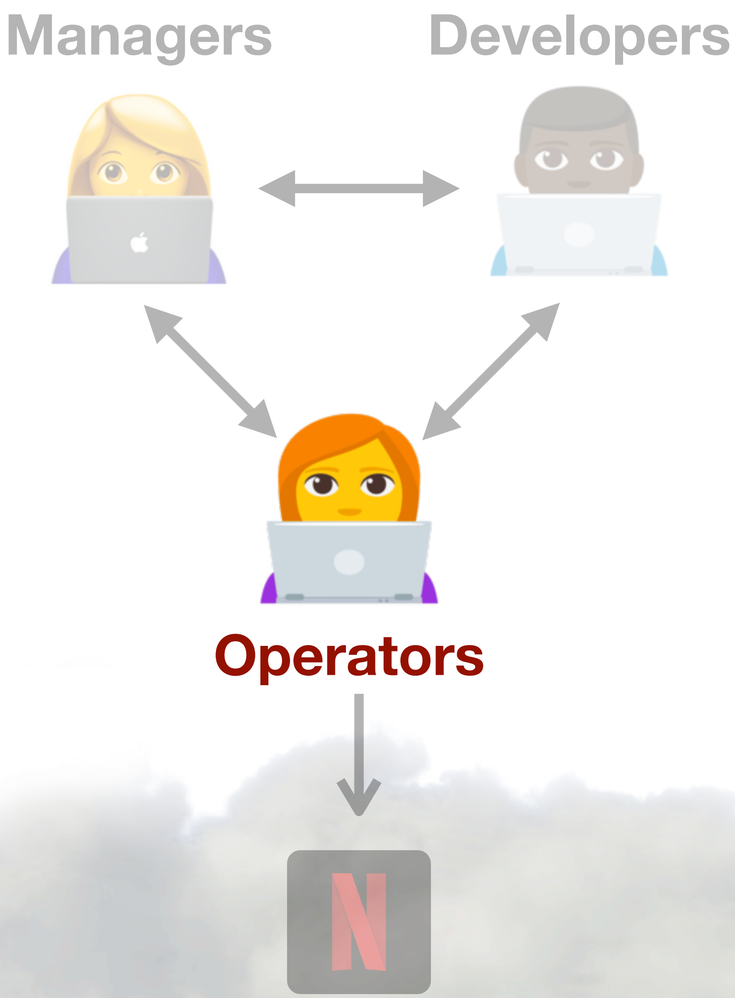
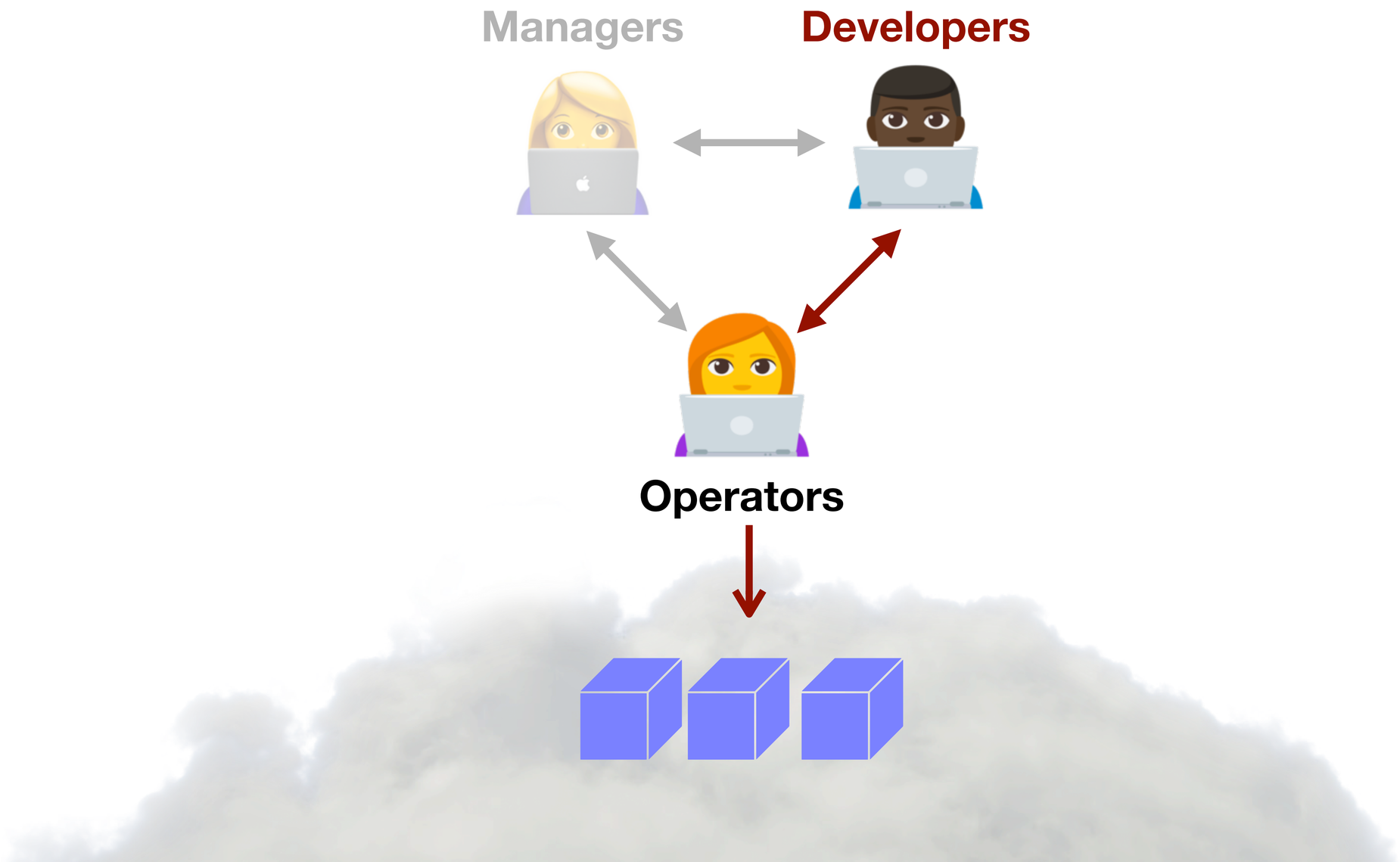
*simplified model

# Every large-scale application team has an operations team




*simplified model

# Operators work with developers to deploy applications on the cloud

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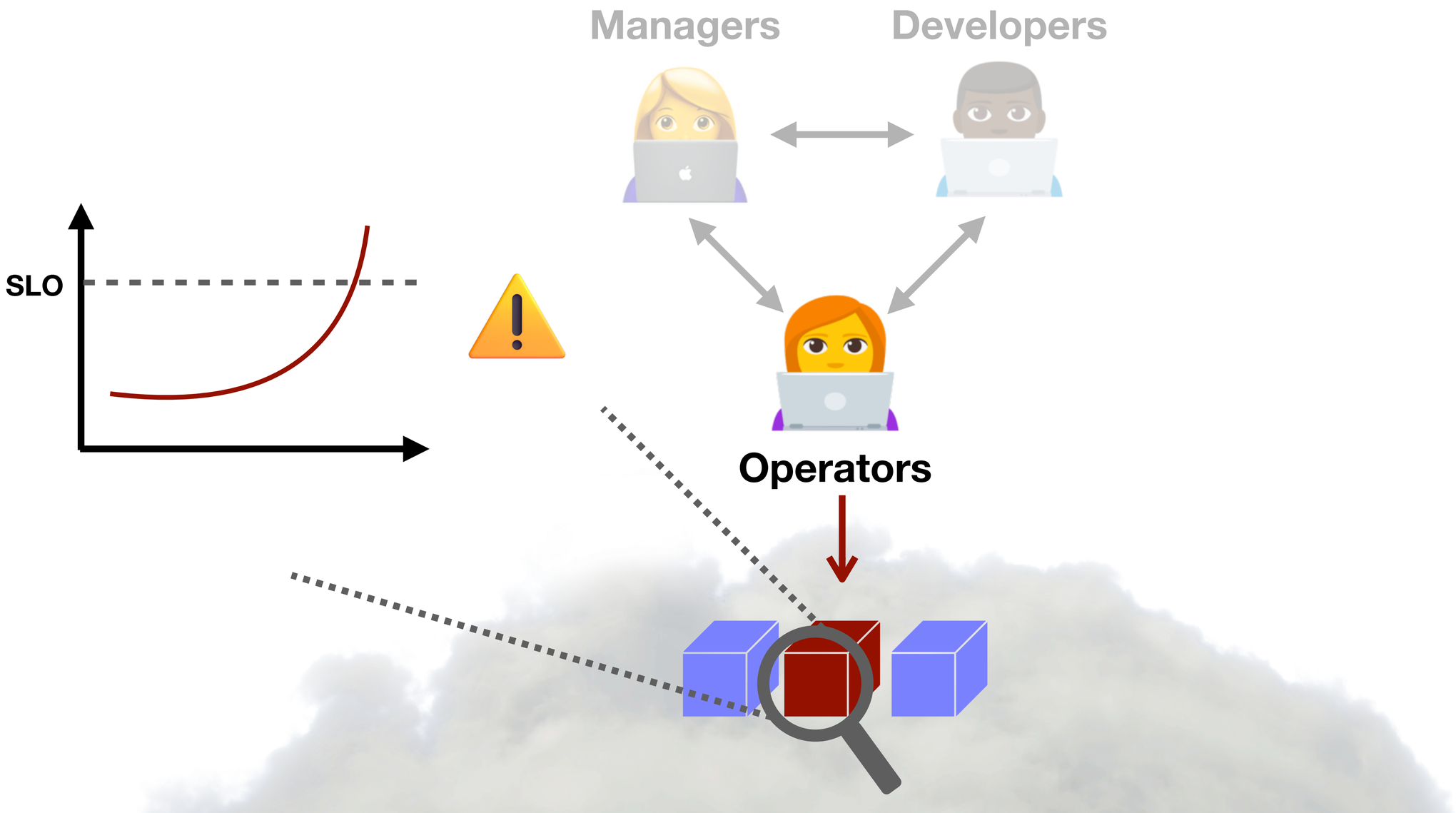
# Operators monitor deployments

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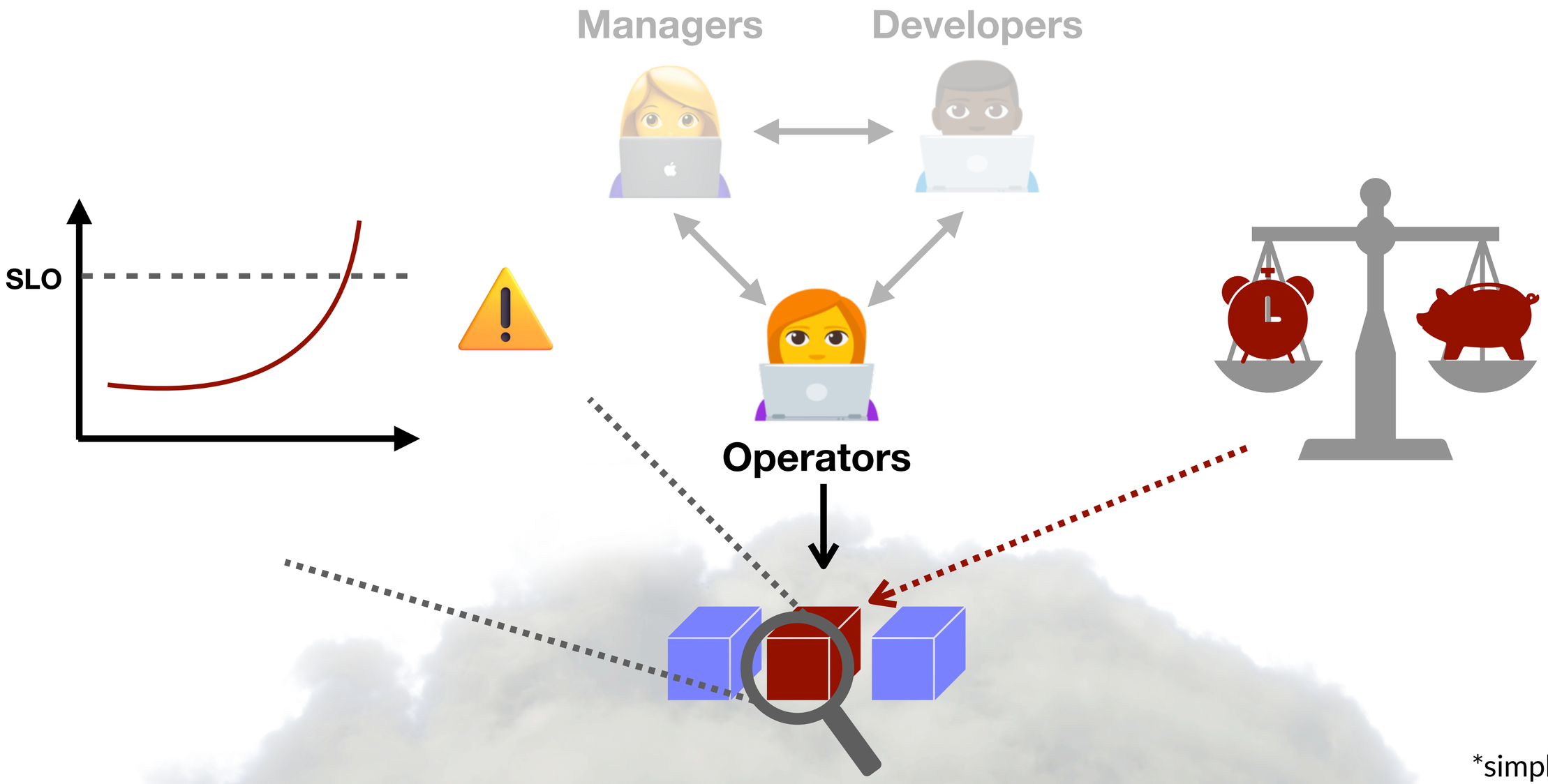
# Operators monitor and make trade-offs

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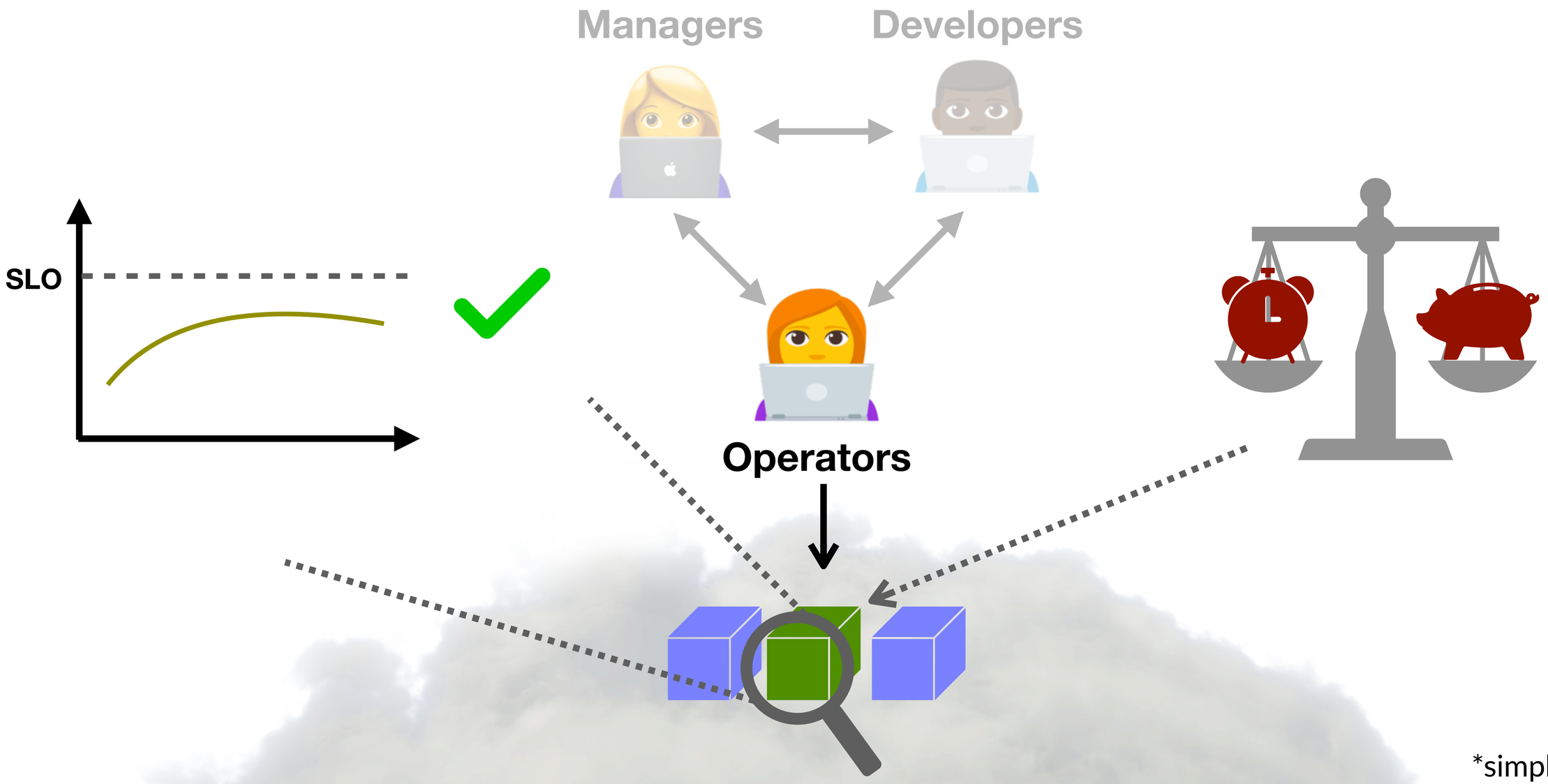
# Operators monitor and make trade-offs to meet service objectives

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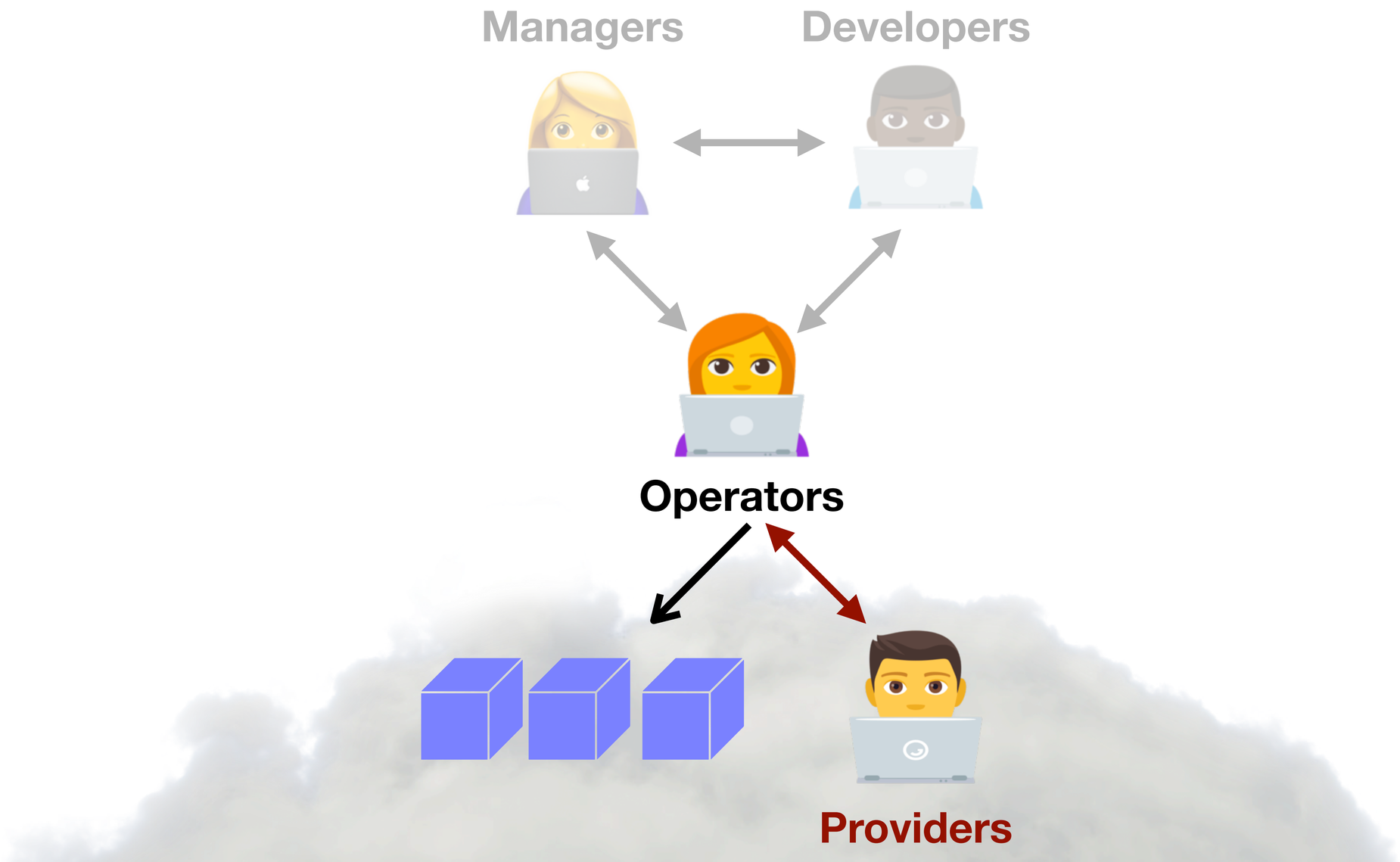
# Operators also work closely with cloud provider teams

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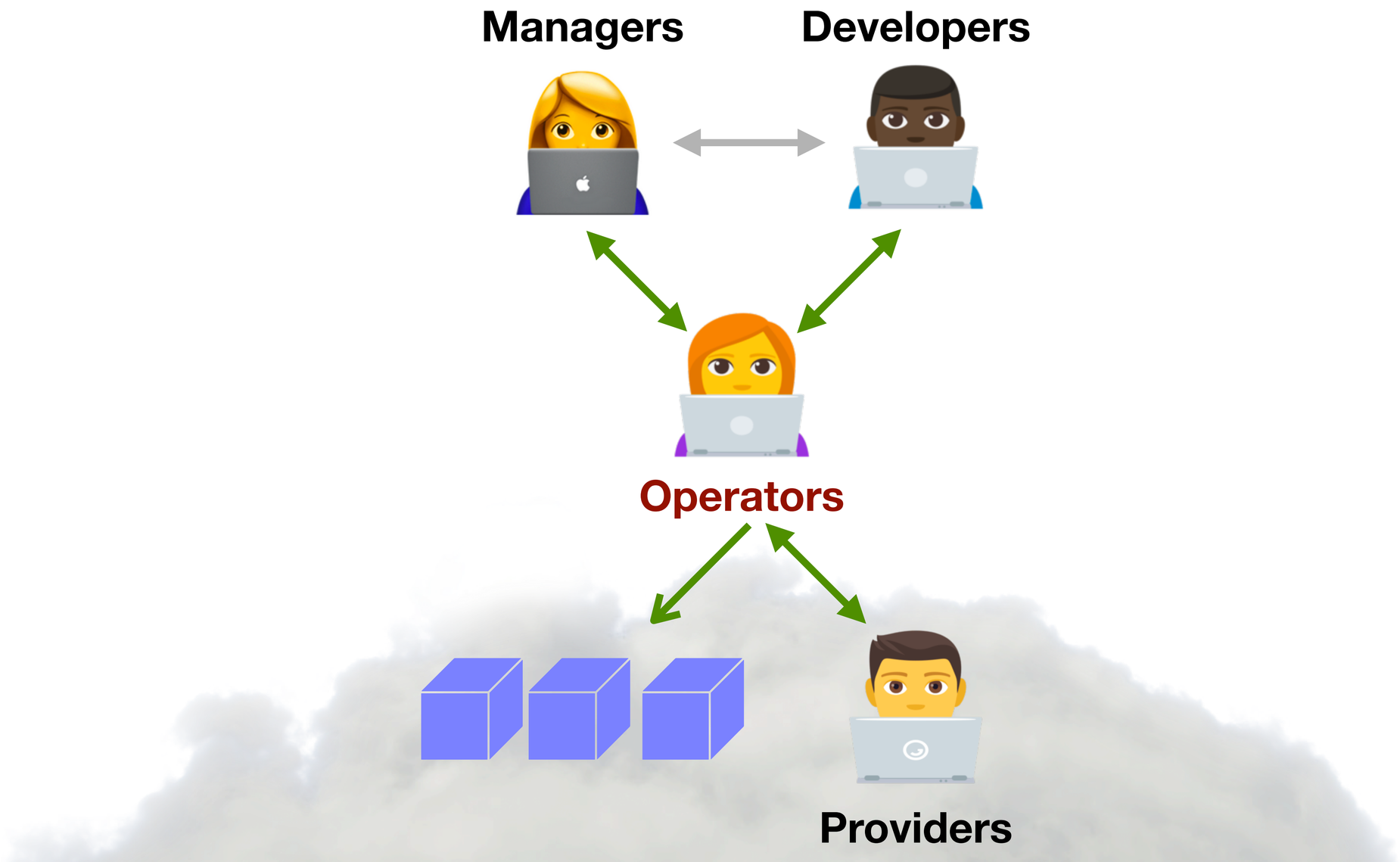
# Operators are the narrow waist to enable cloud carbon awareness!

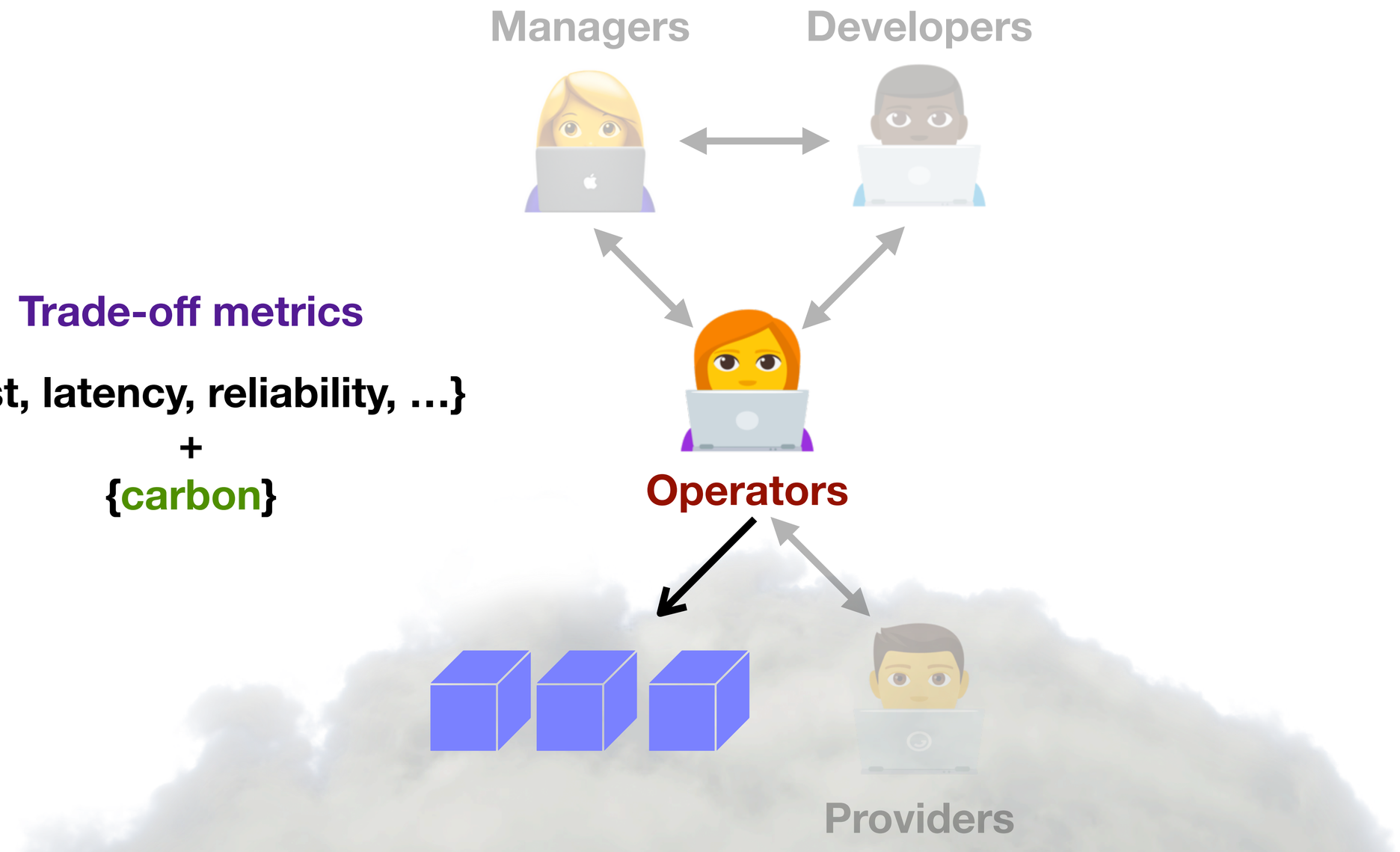



*simplified model

# Viewing carbon as an operations concern

**Trade-off metrics**

**{cost, latency, reliability, …}**
**+**
**{carbon}**

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# Operators can help managers and developers be carbon aware

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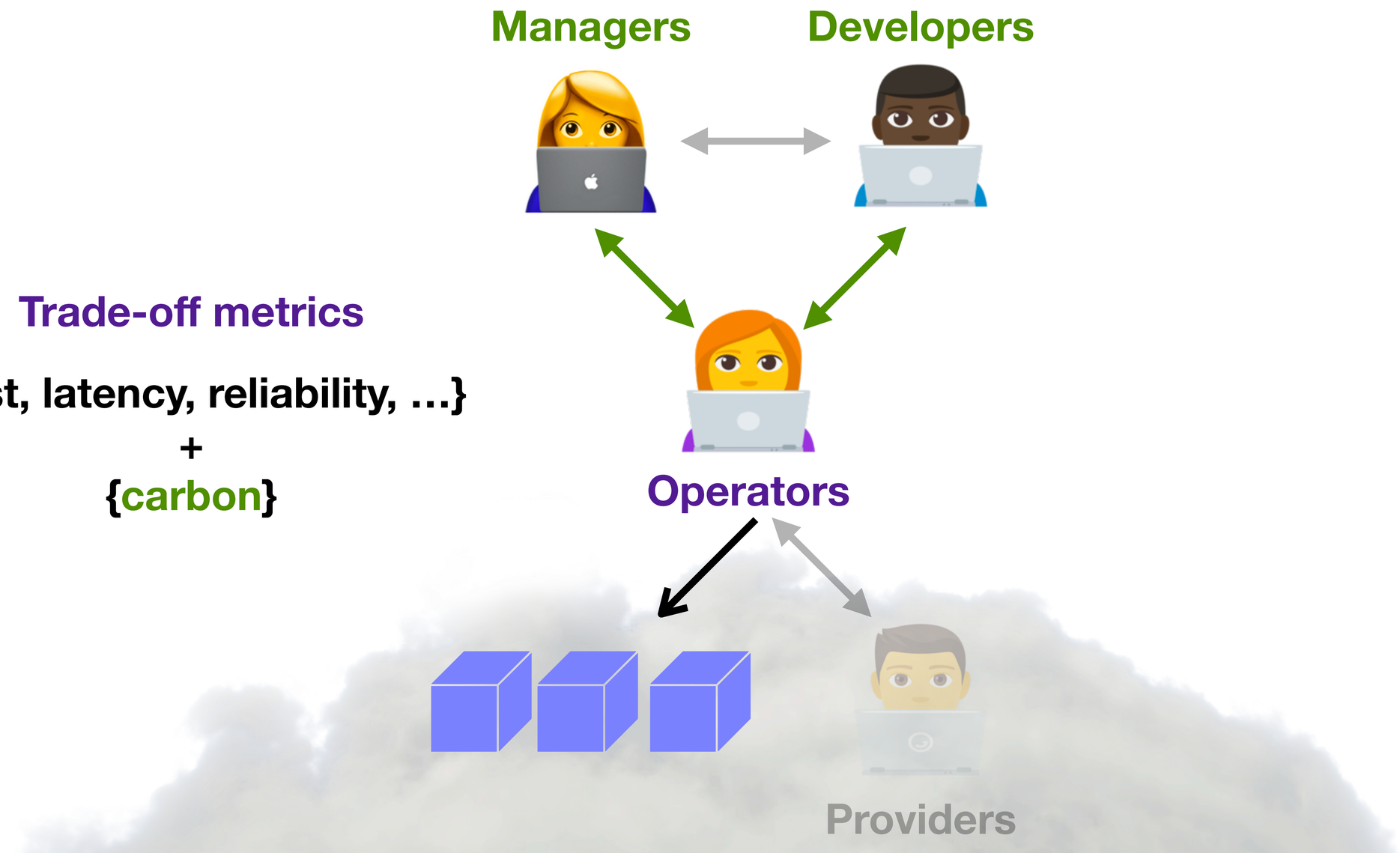


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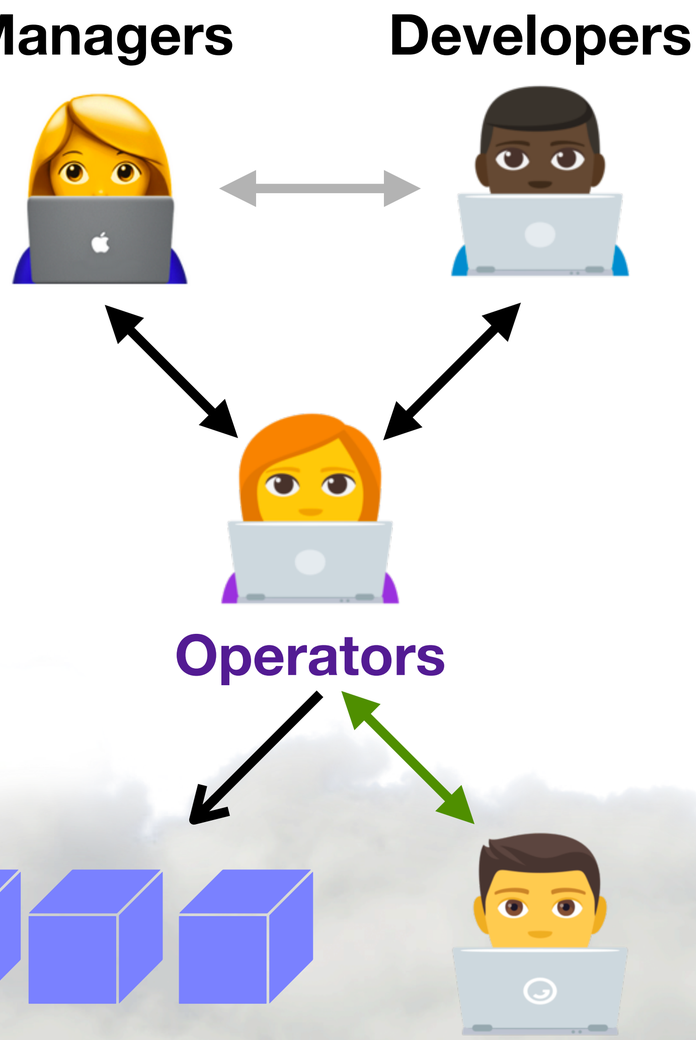
# Operators and providers can communicate visibility to reduce carbon




**Trade-off metrics**

**{cost, latency, reliability, …}**
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**Visibility is needed in both directions!**

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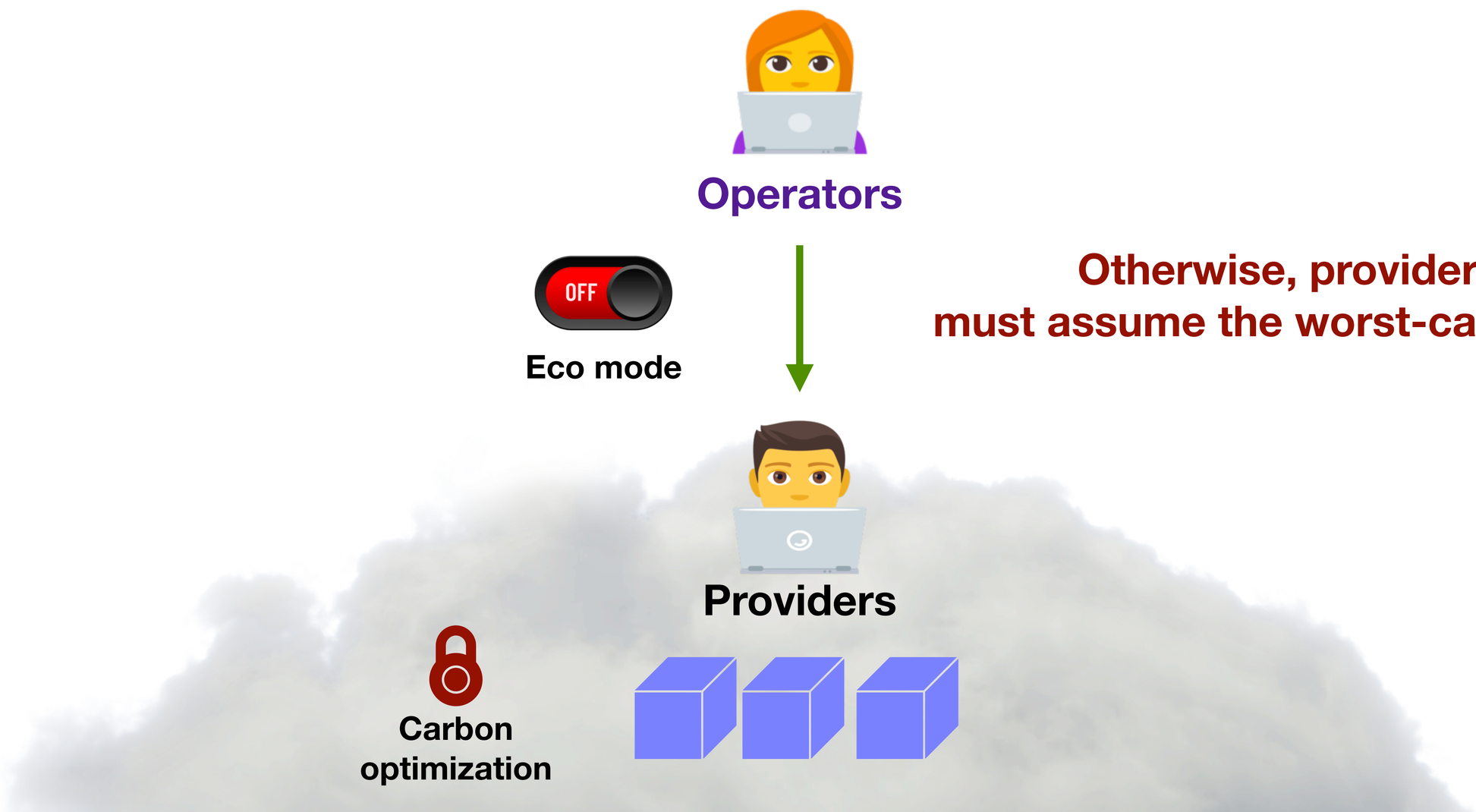
# Operator—>provider communication with application “eco modes”

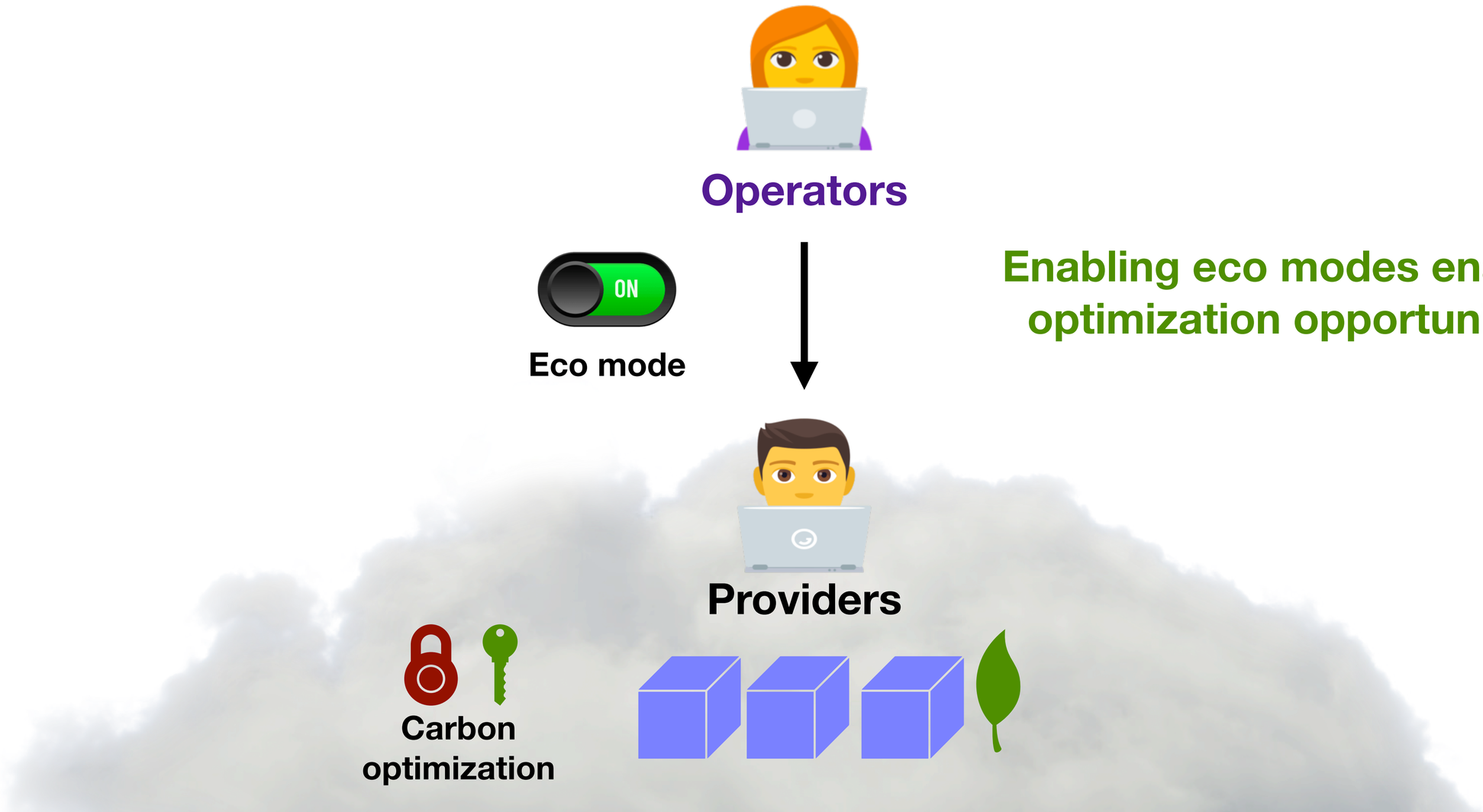
***capture coarse-grained notions of carbon trade-offs***




**Otherwise, providers must assume the worst-case SLOs**

# Toggle applications between power mode and eco mode

***capture coarse-grained notions of carbon trade-offs***




**Enabling eco modes enables optimization opportunities**

# Different eco modes, different trade-offs

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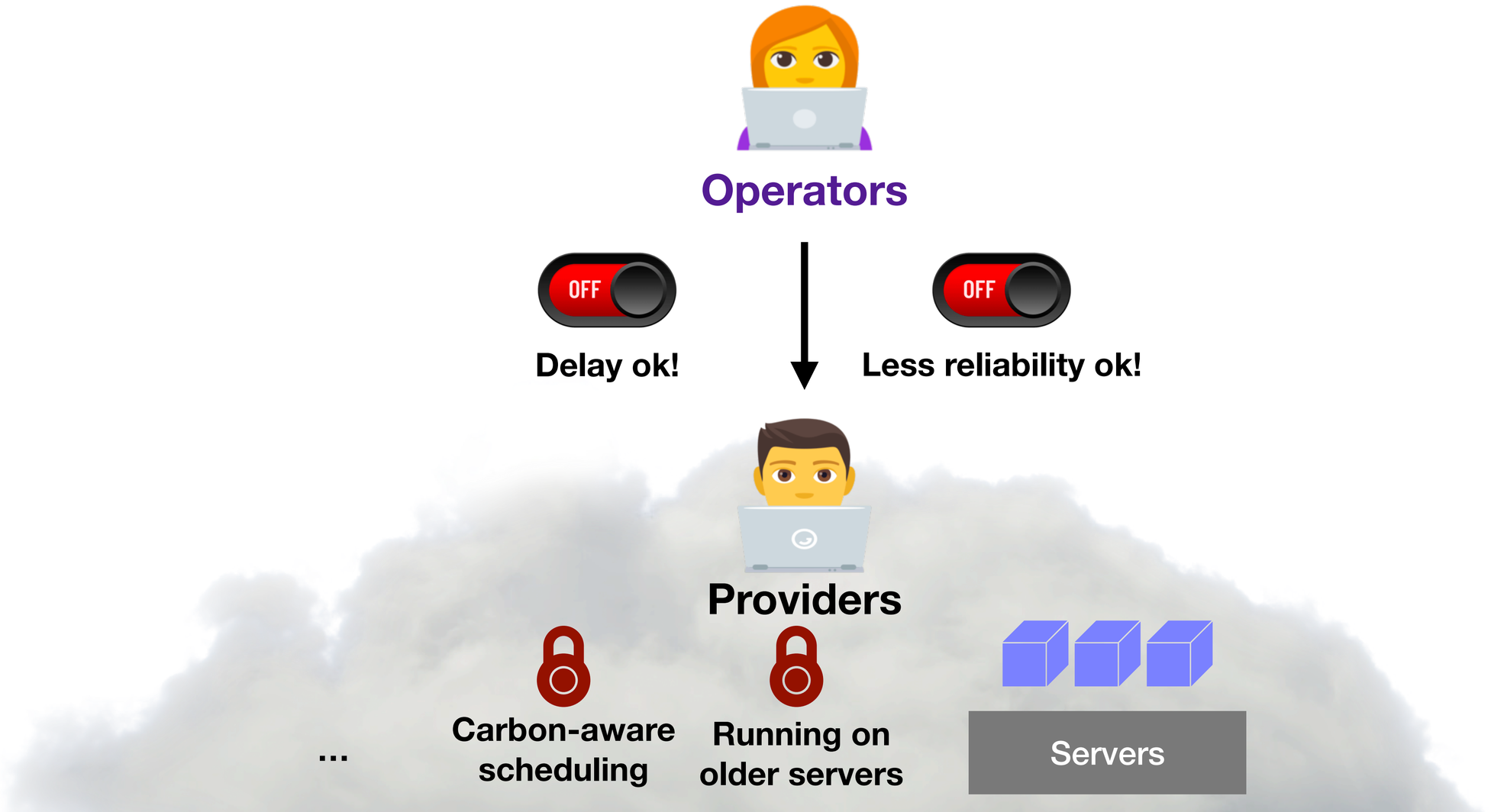

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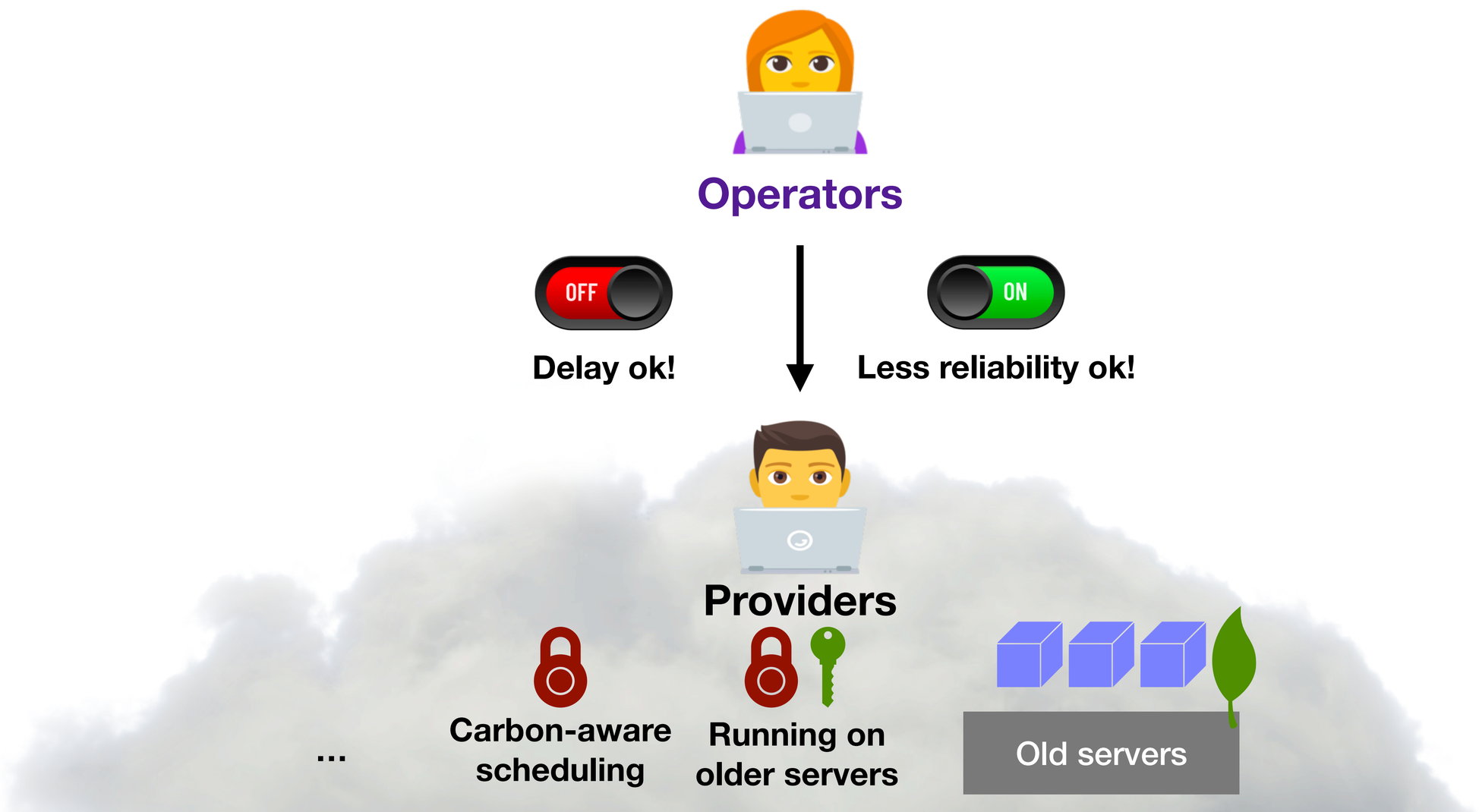

# Developers can extend eco modes by implementing new trade-offs

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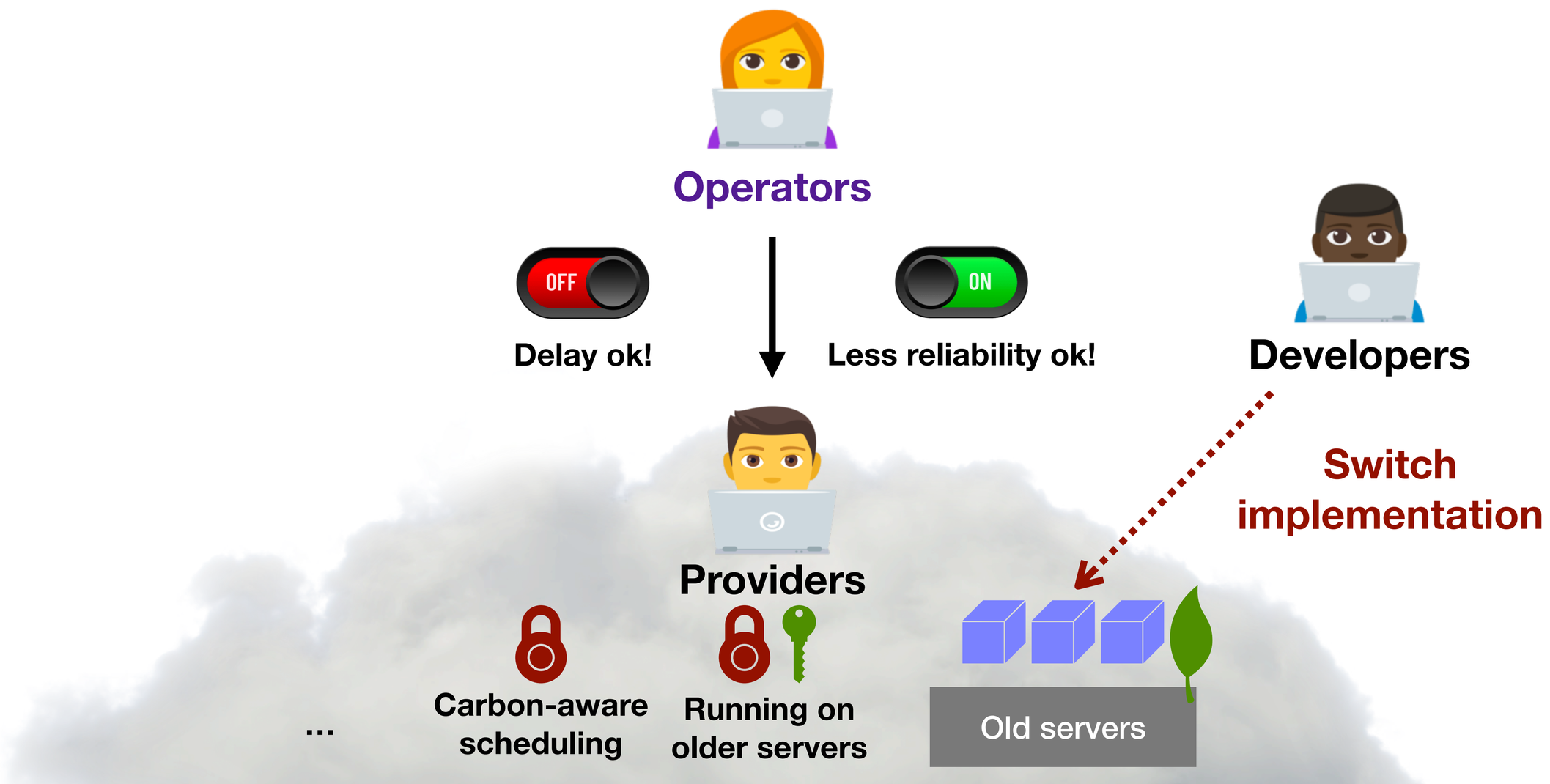
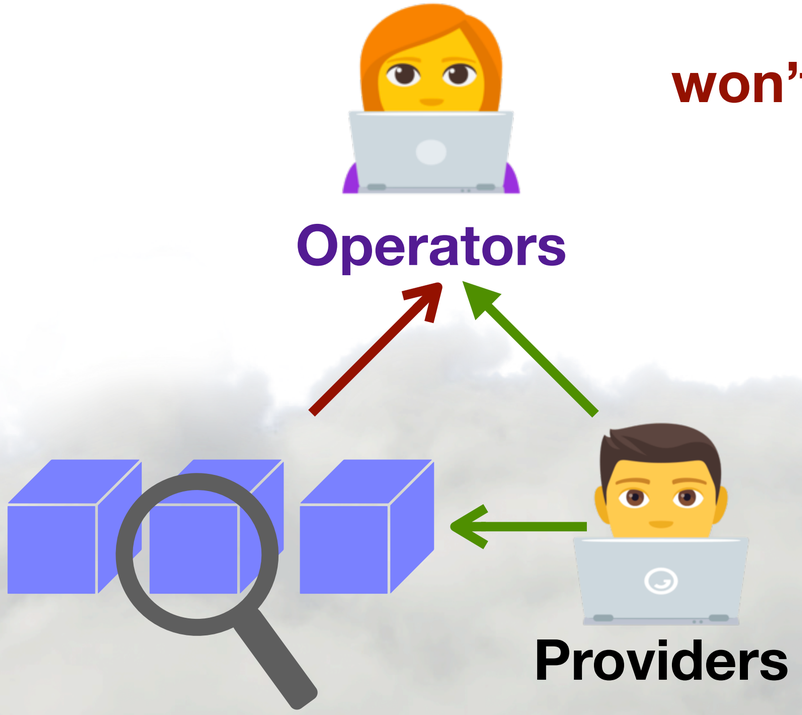


# Provider—>operator communication with service-level carbon metrics

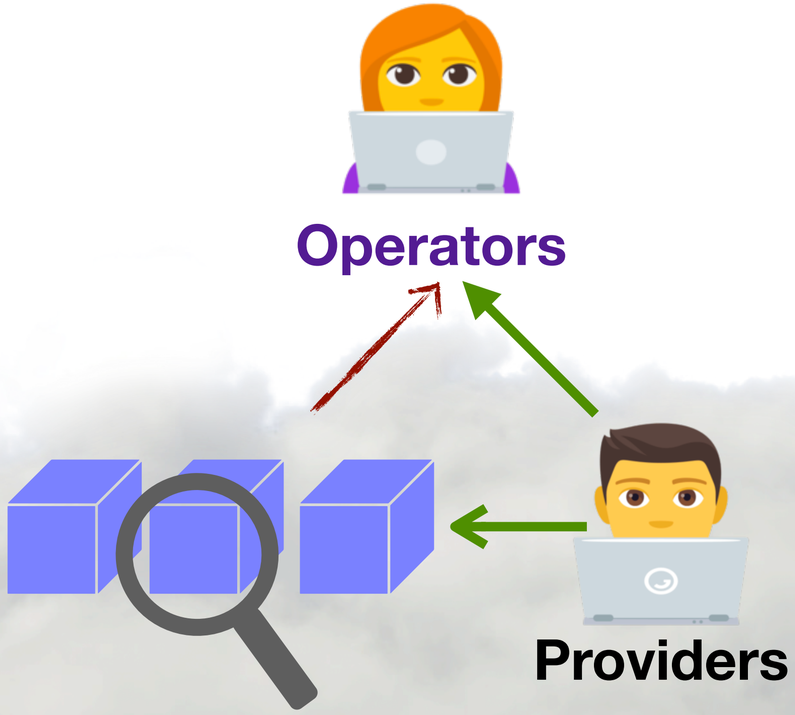
***empower application operators with carbon visibility***




**Otherwise, operators**
**won’t know how to trade-off carbon**

# Approximate metrics are good enough! (for now)

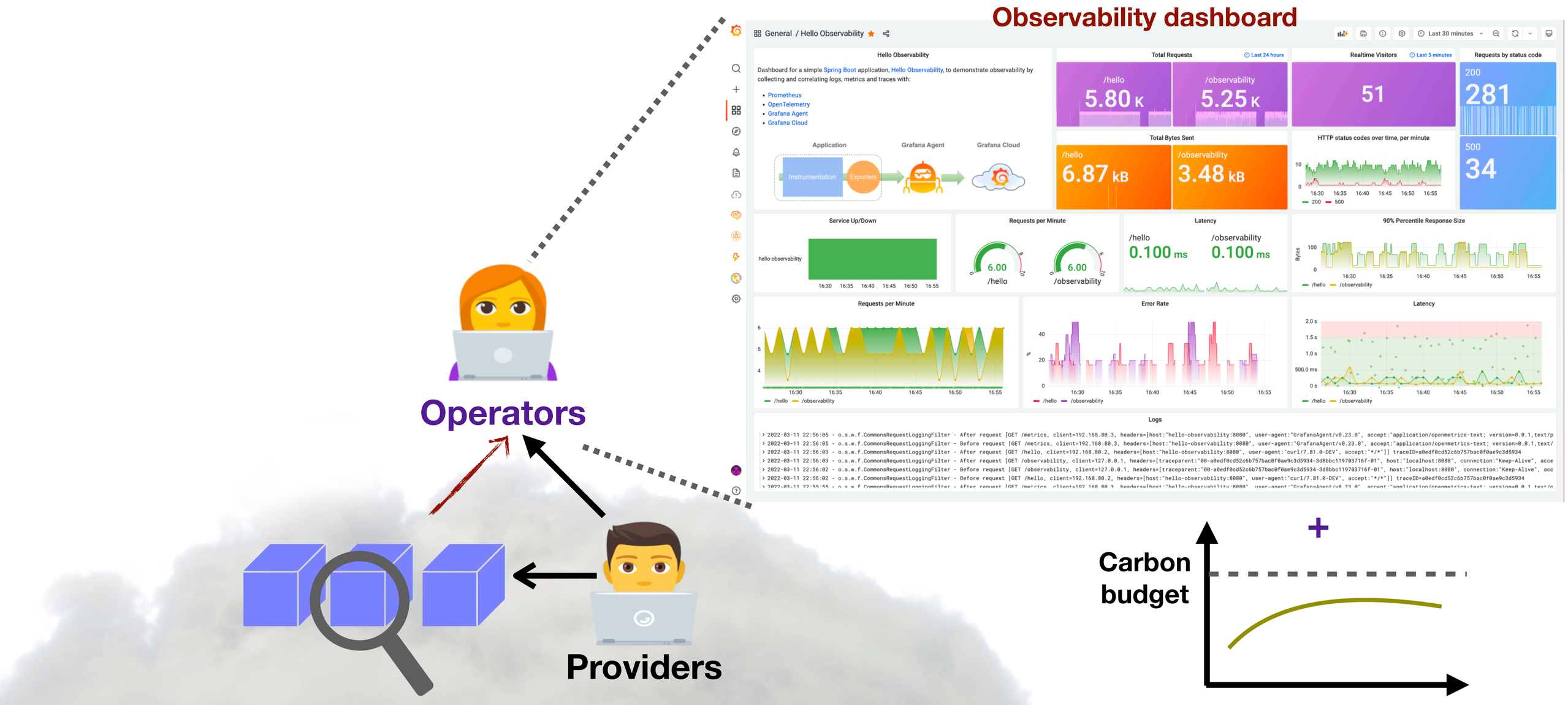
***empower application operators with carbon visibility***




**As long as they enable carbon reduction**

# Integrate carbon into existing operator workflows

***empower application operators with carbon visibility***



# Helps identify carbon hotspots for developers to optimize

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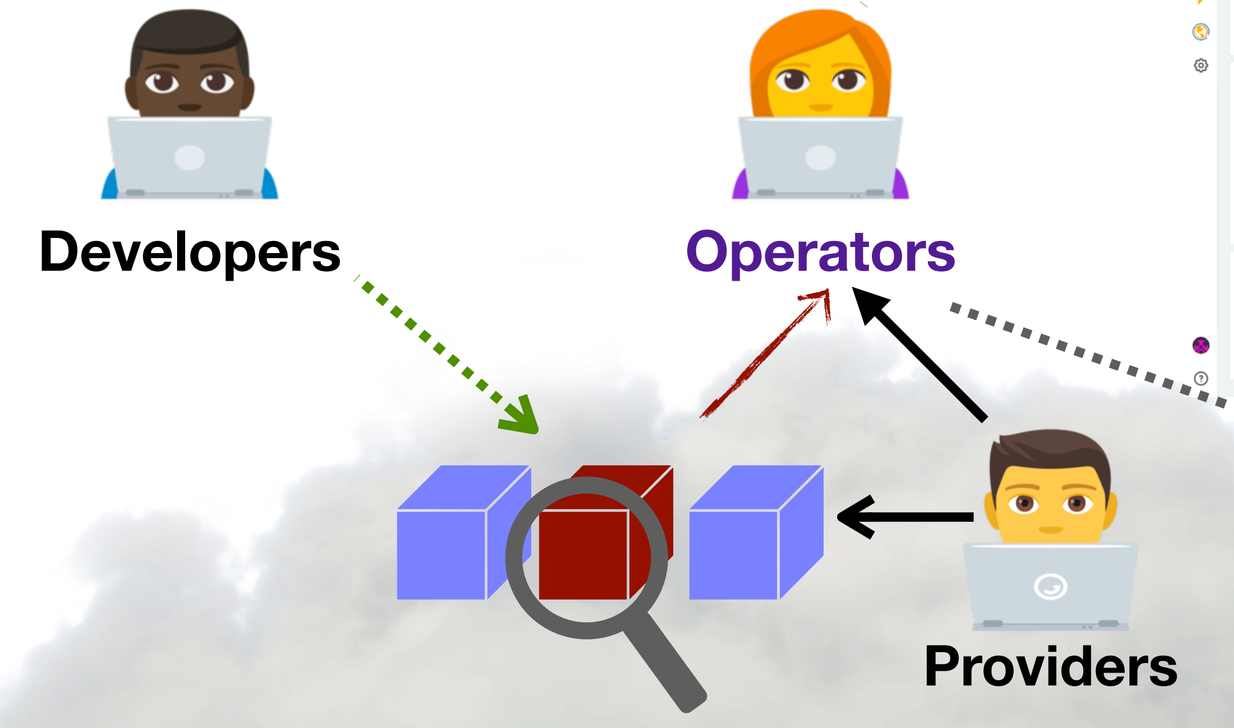


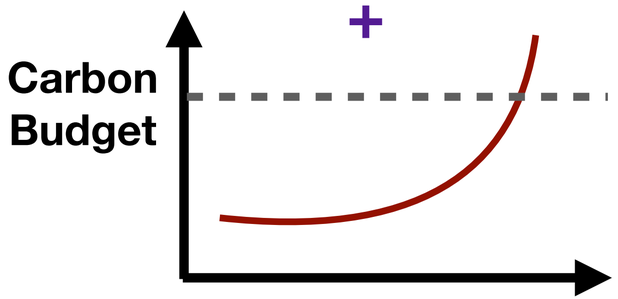

# Carbon knowledge repositories to federate carbon awareness

***"menu cards" for software carbon intensity***

## Key-value stores

| KV-store | Reads | Writes |
|---|---|---|
| **Redis** | 10k req/s | 5k req/s |
| **Memcached** | 12k/s req/s | 4k req/s |

## Deep learning models

| Model | Accuracy | Latency |
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| **CatGPT** | 99% | 64 ms/token |
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*illustrative

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**Standardize carbon benchmarks**

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## Container registry

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**Check out: https://ml.energy/leaderboard/**

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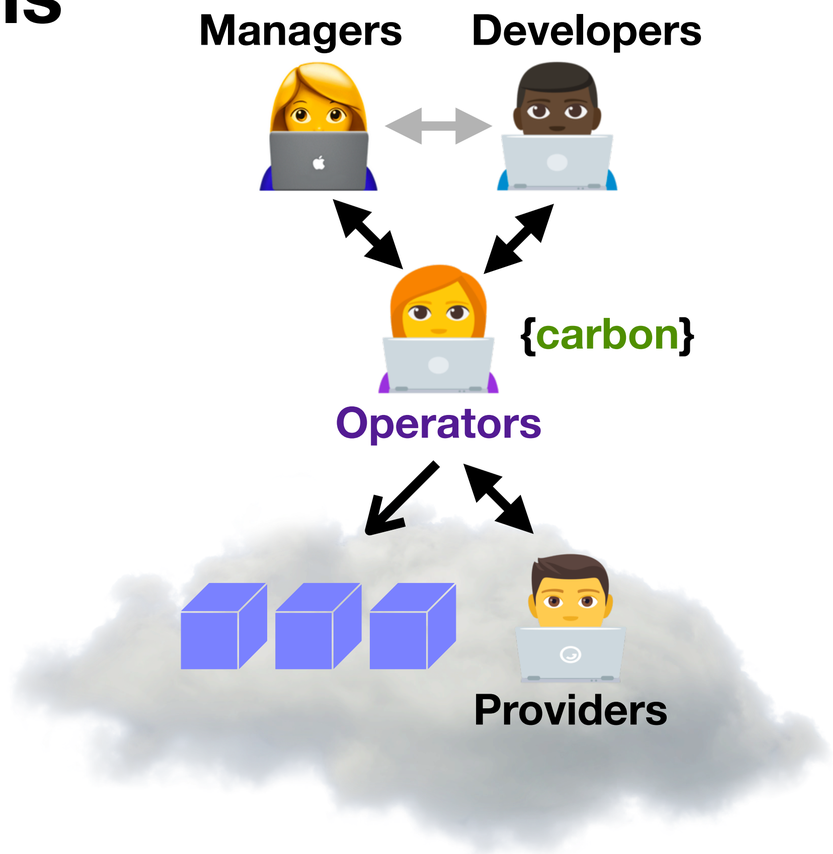
# An agile pathway towards carbon-aware clouds

1. **Federate carbon responsibility and tools** with operators as the narrow waist

2. **Provide actionable visibility** into carbon emissions

3. **Centralize configurable optimizations** for SLO-aware carbon reduction




Thanks!

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