How to buy a Cloud

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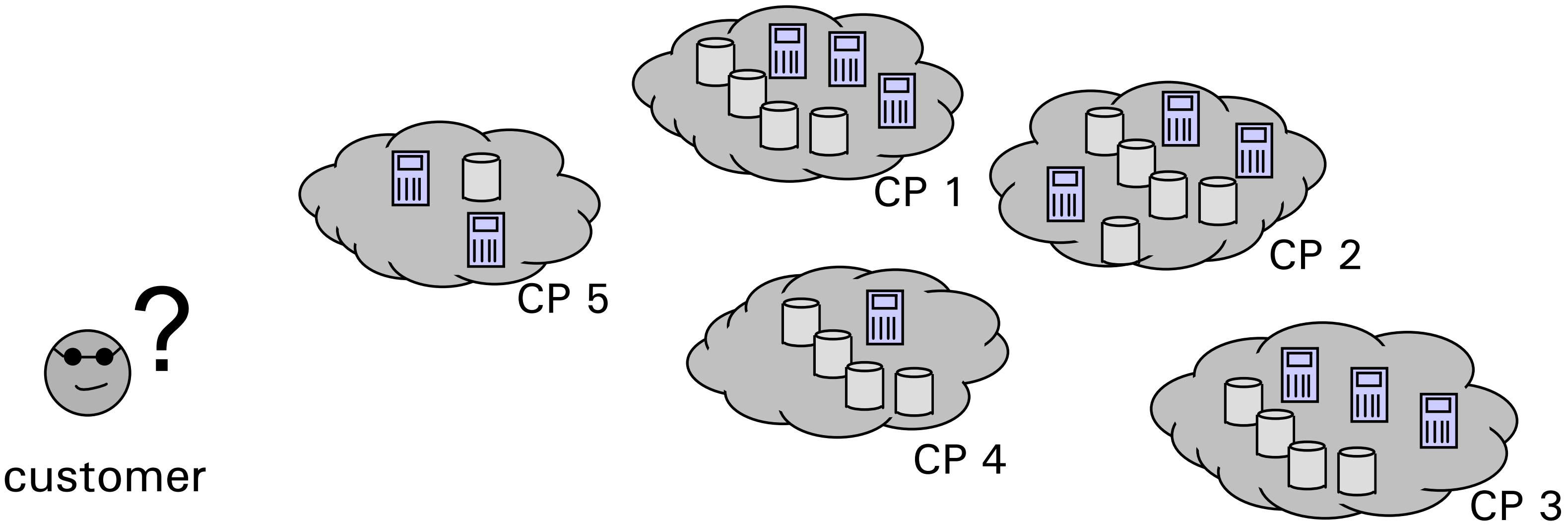
Concepts

- Why open system of cloud resource provisioning?
  - provider independent.
  - allows combinations of different providers.
  - better allocation of resources.
  - cloud resources are perishable (use it or lose it).
- If its such a good idea, why aren’t we using it already?
  - Customer lock-in.
  - No common architecture for accounting and charging.
  - API issues

Motivation



- Assuming that the various resources are owned by different organizations, how can the customer construct a virtual computation platform from these resources?
- Voucher analogy

Cloud Exchange

- The Cloud exchange is an on-line site where
  - cloud providers place quotes for their available cloud resources
  - customers browse for offers for cloud resources
- Futures Market
  - advance bookings
- Spot Market
  - used to allocate resources that have not been previously reserved.
- Requirements
  - transparency (to ensure fairness).
  - assurances (to both buyer and seller).
- Supports overlay providers (delegation)

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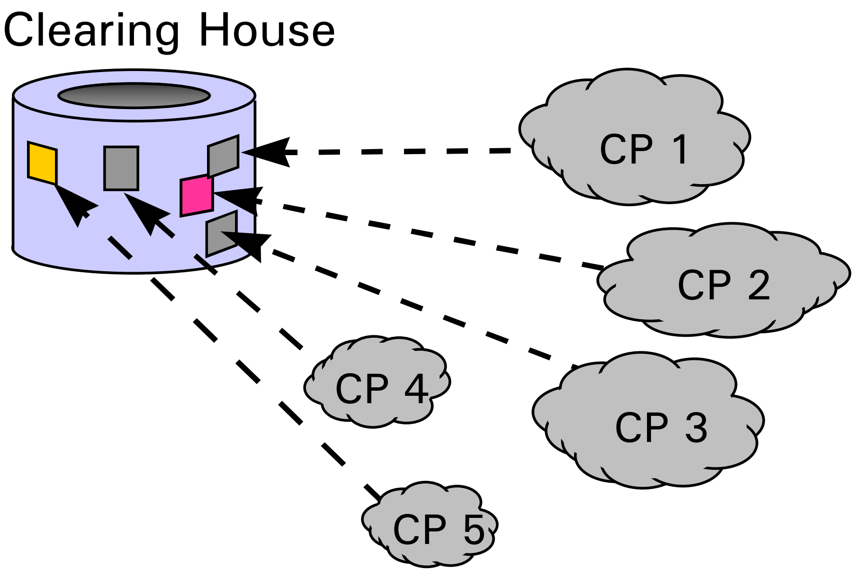
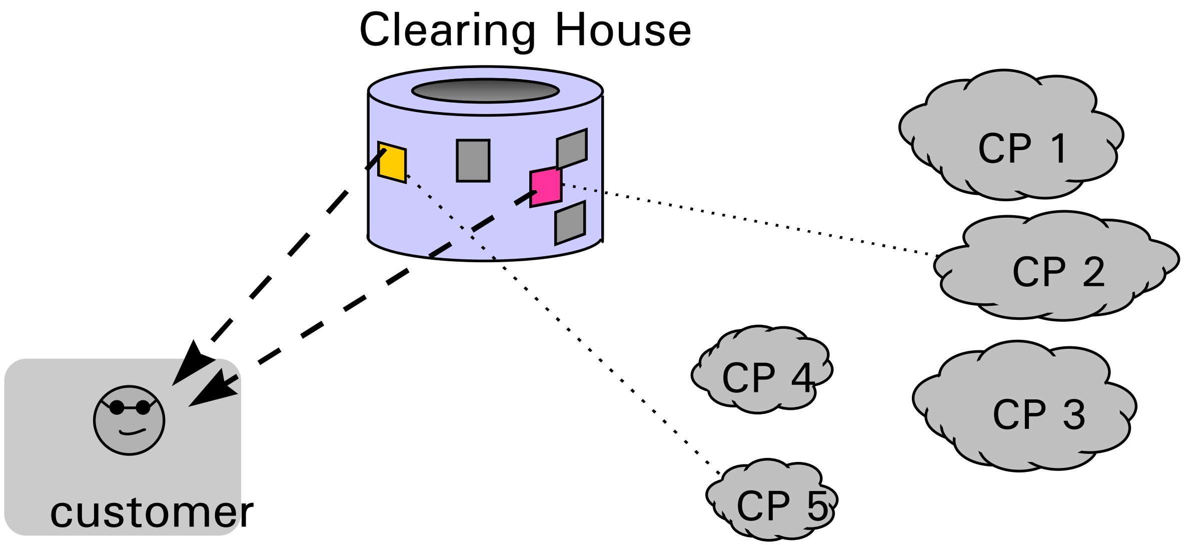
Cloud Resource Exchange (CRX) Architecture (1)



Example of Spot Market Operation

The Clearing House acts as a repository of all the offers for bandwidth issued by the various cloud providers (CPs).

CRX Architecture (2)



Customer finalizes the path selection by downloading the offer credentials.

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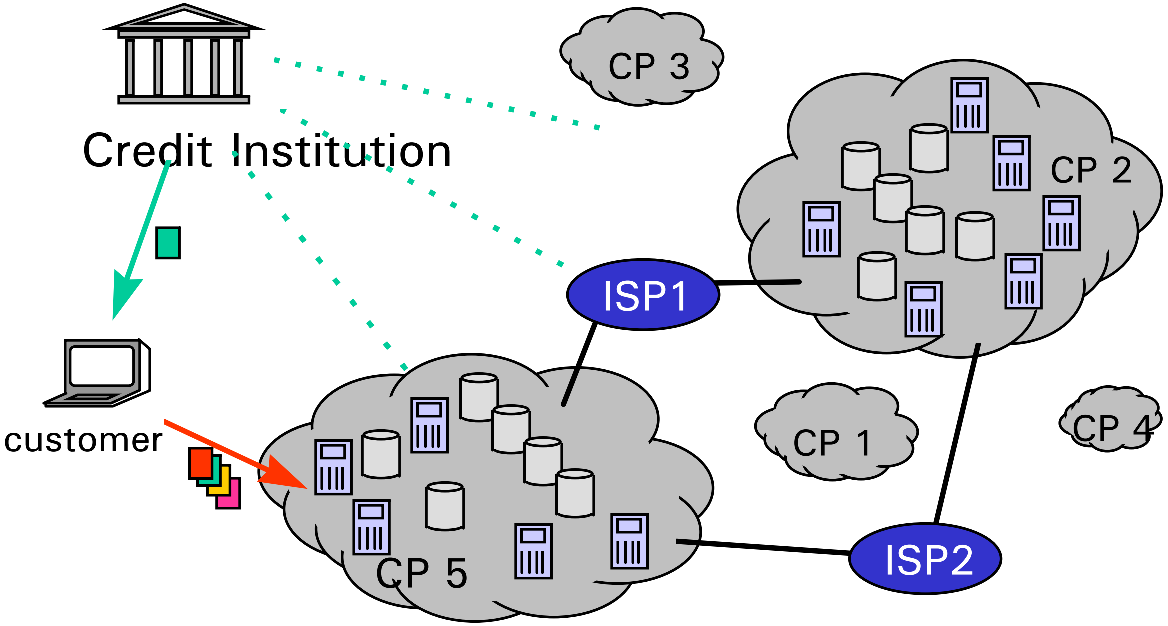
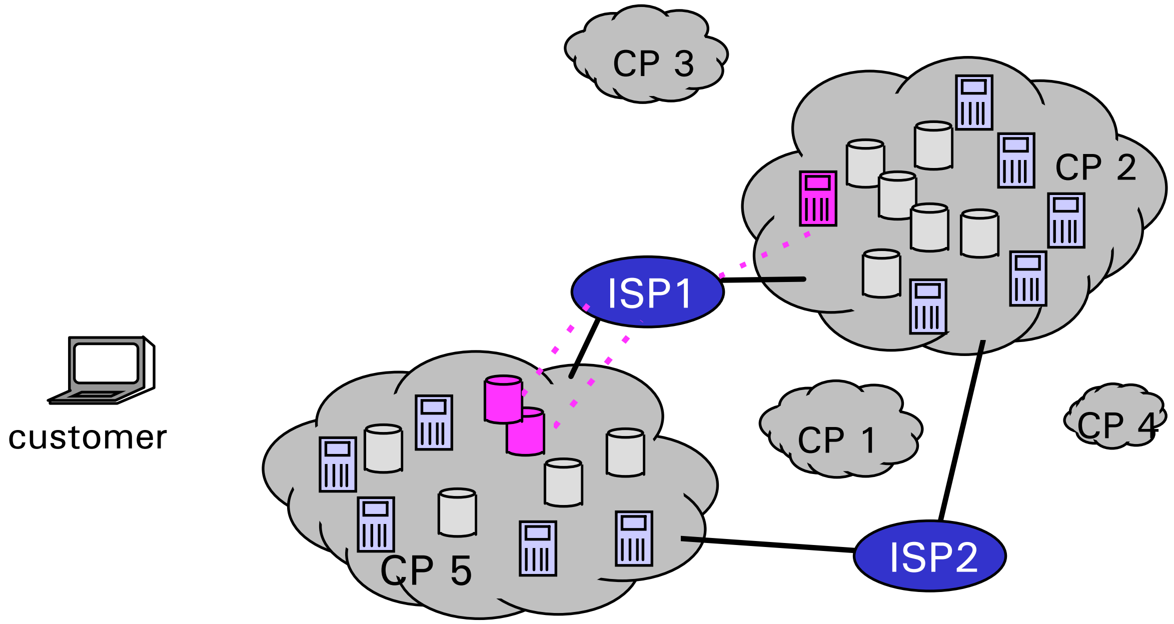
CRX Architecture (3)



The customer issues a request by sending the offer credentials collected from the CRX Clearing House along with a credit-worthiness credential issued by his or her credit institution.

CRX Architecture (4)



Configuration complete:

Storage servers from CP5,
Computation server from CP2 and
Communication links from ISP 1

CRX Architecture (5)

- Operation of the Futures Market
  - In the spot market, offers have immediate effect.
  - In the Futures market, offers take effect in the future.
    - thus CPs must be informed in advance.
  - Carry out “notional” negotiation (same as spot market).
  - Reservation Credential(s) sent to the user.
  - When resource is required (within the reserved period), user initiates reservation process.
    - in this case only the reservation credentials need be sent.

Implementation (1)

- Trust Management Framework
  - credentials contain public keys of *authorizer*, *licensee*, and *conditions* (code that describes what is contained in the credential)
  - Credential signed by the *authorizer*.

```
Keynote-Version: 2
Local-Constants: ALICE KEY = "rsa-base64:MCgCIQGB0f8...”
      CG KEY = "rsa-base64:MIGJAo..."
Authorizer: CG KEY
Licensees: ALICE KEY
Conditions: app domain == "CRX" && currency == "USD"
      && &amount < 5.01 && date < "20150824" -> "true";
Signature: "sig-rsa-sha1-base64:QU6SZtG9R3IXXAU9vRDBgu..."
```

Implementation (2)

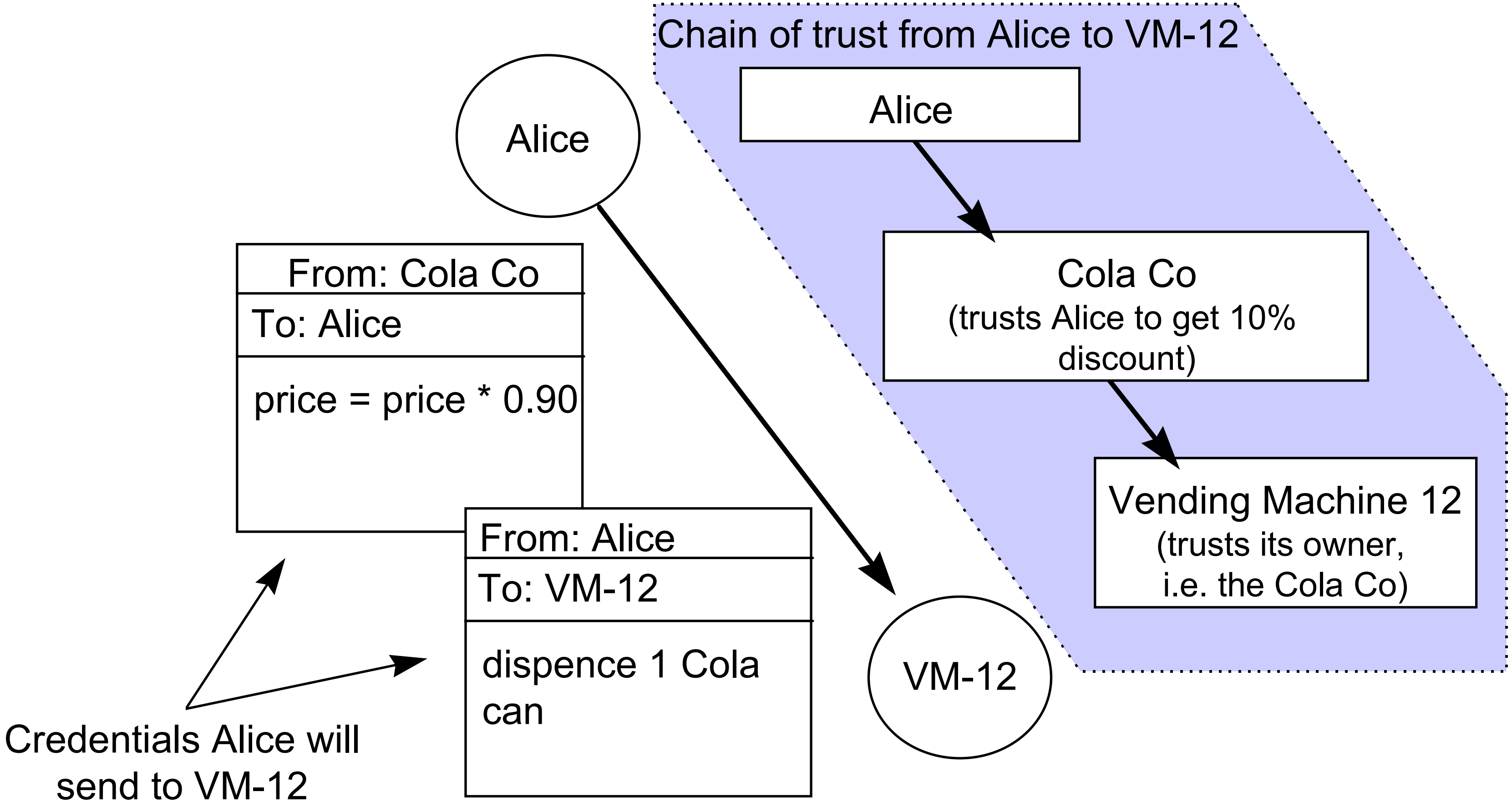
- Trust Management Framework
  - Each entity trusts itself.
    - basic policy allows other entities to be trusted (conditionally)
    - additional credentials allow this trust to be extended (conditionally).
  - For a request to be granted it must be consistent with existing policy.
    - otherwise the request must supply credentials to extend the policy.
    - if not, the request will be denied.
  - Keynote library allows credentials to be verified and integrated into the policy automatically.

Example

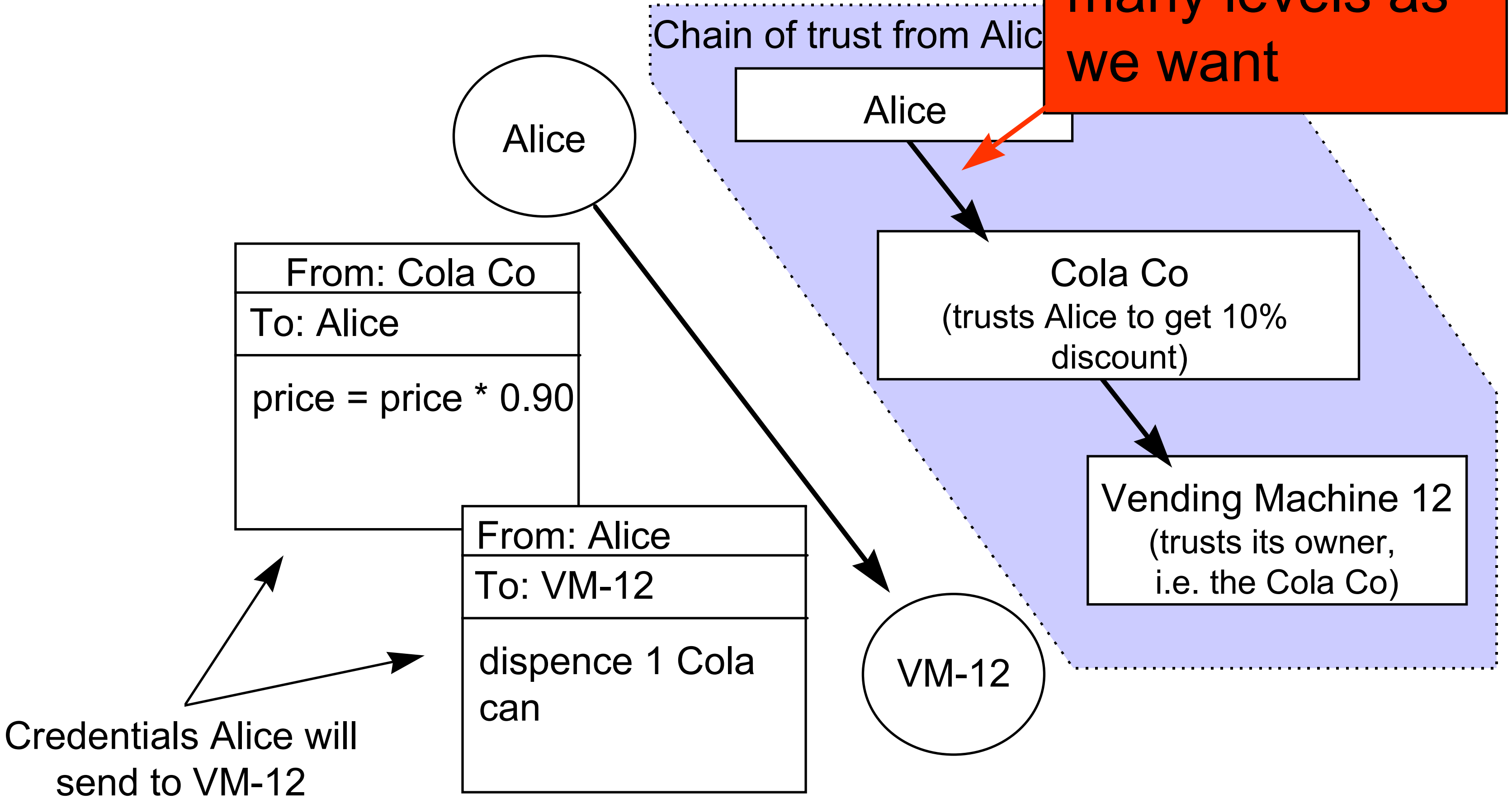
- Vendor wants to give discount to “preferred” customers
  - needs to instruct vending machines to give 10% discount to authorized users
  - usual problems
    - list of users not known in advance, lots of vending machines, etc.
- Vendor issues a credential to each “preferred” customer
  - command example (pseudo code)

    ```
    if (date < 20151231 && price > $1) then price = price * 0.9
    ```
  - Authorizer is vendor (signs credential)
  - Licensee is customer’s public key

Trust Model (2 level)


Chain of trust from Alice to VM-12
Alice
Cola Co
(trusts Alice to get 10% discount)
Vending Machine 12
(trusts its owner, i.e. the Cola Co)
Alice
VM-12
From: Cola Co
To: Alice
price = price * 0.90
From: Alice
To: VM-12
dispence 1 Cola can
Credentials Alice will send to VM-12

Trust Model



We can add as many levels as we want

Example

- Customer establishes session with vending machine
  - any mechanism is acceptable
  - can deal with issues such as replay attacks, secrecy etc.
- Customer sends request with discount credential
- Vending machine
  - matches request signature with public key included in vendor credential
  - evaluates request
  - declares outcome (final sale price)
  - note that payment can be effected using trust management (micropayments) or other traditional form (e.g. coins)

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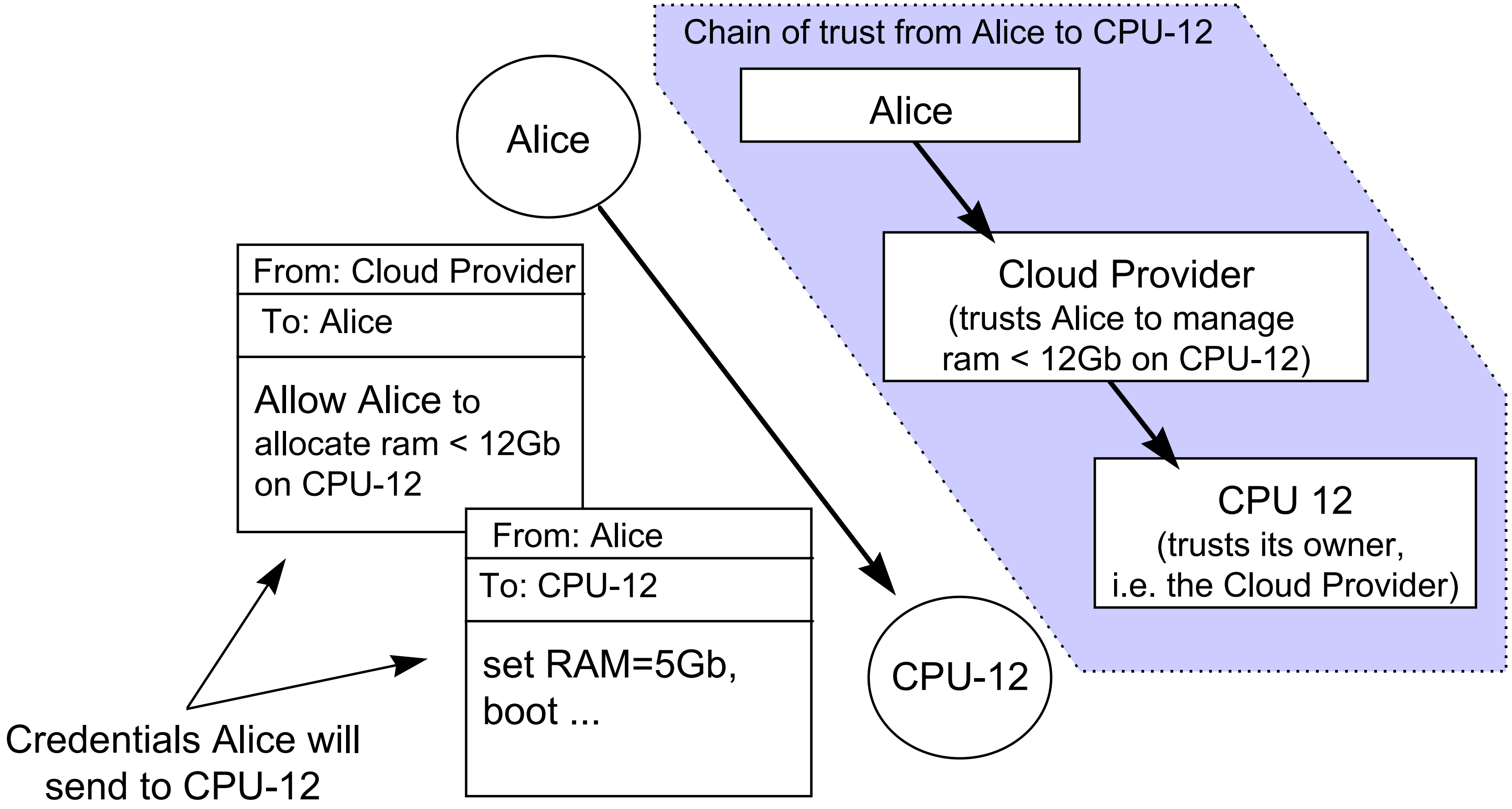
Implementation (3)



Chain of trust from Alice to CPU-12

Alice

Cloud Provider
(trusts Alice to manage
ram < 12Gb on CPU-12)

CPU 12
(trusts its owner,
i.e. the Cloud Provider)

From: Cloud Provider
To: Alice
Allow Alice to allocate ram < 12Gb on CPU-12

From: Alice
To: CPU-12
set RAM=5Gb, boot ...

Credentials Alice will send to CPU-12

Problems

- Overbooking
  - CPs do not know in advance how many offers will be exercised
- Loss of Quality
  - What happens if a provider fails to deliver on their promises
- Revocation
  - What if one or more actors change their minds?

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Conclusions

- Model accommodates both “instant” purchases of bandwidth and advanced purchases
  - CPs can plan ahead their resource allocation strategies
  - CPs can get better prices for unused capacity.
- The entire protocol is efficient requiring only a few exchanges between a buyer and various sellers to effect a reservation.
- CRX system can be deployed with minimum disruption.

Conclusions

- Credit Institution(s) link buyers and sellers
  - transactions can take place between buyer and seller without previous business relationship.
  - Allows cloud resource market to work freely with the buyer being able to select the seller offering the best value for money.
- Keynote-based micro-payment framework makes entire system efficient and scalable.

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Conclusions

- The CRX model allows the presence of multiple entities for each role (*i.e.,* we can have multiple Credit Institutions, Clearing Houses, buyers and sellers) operating within a single market. This increases the competition and overall reliability of the entire system