More Than The Sum Of Its Things

Resource Sharing Across IoTs at The Edge

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SEC '20

What are IoTs?

Subset of fields in which IoTs are being used

What are IoT Middlewares?

Camera Surveillance	Smart Video-conferencing	Emotion Detection Journal

Middleware

IoT Middleware

		Agent-based approach
Impala [149]	DD-DeD	RA, RM
Smart messages [150]	DD-ND	RA, RM
ActorNet [151]	DD-DeD	RA
Agilla [28]	DD-DeD	RA, RM, RCA
Ubiware [152]	DD-DeD, DD-SD	RA, RM, RCA
UbiROAD [153]	CD-SD	RM
AFME [154]	CD-DD	RA
MAPS [155]	DD-DeD	RA, RM
MASPOT [147]	DD-DeD	RA, RM, RCA
TinyMAPS [156]	DD-DeD	RCA
		Tuple-space approach
LIME [160]	CD-DeD, CD-SD	RM
TeenyLIME [162]	CD-DeD, CD-SD	RM
TinyLIME [161]	CD-DeD, CD-SD	RM
TS-Mid [164]	CD-DeD, CD-SD	RM
A3-TAG [165]	CD-DeD, CD-SD	RM
		Database approach
SINA [166]	DD-DeD	RM
COUGAR [168]	DD-ND	RM
IrisNet [169]	DD-SD	RA, RM, RCL
Sensation [170]	CD-DeD	RM
TinyDB [69], [171]	DD-DeD	RM
GSN [172]	DD-DeD, DD-SD	RA, RM
KSpot [173]	DD-SD	RM
HyCache [174]	DD-DeD	RM
		Application-specific appro
AutoSec [175]	CD-SD	RA, RM, RCA, RCL
Adaptive middleware [176]	CD-SD	RA, RM
MiLAN [177]	CD-SD	RA, RM, RCA
TinyCubus [178]	CD-SD	RA, RM
MidFusion [179]	CD-SD	RA, RM, RCA
Legend Not supported (NS) No information (NI)	Centralised discovery (CD) Distributed discovery (DD) Device discovery (DeD) Network discovery (ND) Service discovery (SD)	Resource allocation (RA) Resource monitor (RM) Resource composition (RC) - Adaptive (A) - Predefined (P) Resource conflict (RCL)

		Functional requirement
	Resource discovery	Resource management
		Event-based approach
Hermes [79]	CD-DD	RM
EMMA [27]	CD-DeD, CD-SD	RM
GREEN [81]	DD-ND	RM
RUNES [82]	CD-DeD, CD-SD	RM, RCA
PRISMA [29]	CD-DD	RM
SensorBus [87]	CD-DeD	RM
Mires [88]	CD-DeD, CD-SD	RM
		Service-oriented approac
Hydra [101]	DD-DeD, DD-SD	RA, RM, RCP
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KASOM [110]	DD-SD	RA, RM, RCA
CHOReOS [112]	DD-DeD, DD-SD	RA, RM, RCA
MOSDEN [46]	DD-DeD, DD-SD	RA, RM, RCP
Xively [99]	DD-DeD, DD-SD	RA, RM
CamIoT [98]	DD-DeD, DD-SD	RA, RM
Echelon [118]	DD-DeD, DD-SD	RA, RM
		VM approach
Maté [125]	DD-DeD	RA, RM
VM* [128]	DD-DeD	RM
Melete [130]	DD-DeD	RA, RM, RCA
MagnetOS [132]	DD-DeD	RA, RM, RCA
Squawk [133]	DD-DeD	RA, RM
Sensorware [129]	DD-DeD	RA, RM, RCA
Extended Maté [137]	DD-DeD	RA, RM
DVM [138]	DD-DeD	RA, RM, RCL
DAVIM [139]	CD-DD	RA, RM
SwissQM [140]	DD-DeD, DD-SD	RA, RM, RCA
TinyVM [141]	NI	NI
TinyReef [1231	NI	NS

Non Exhaustive List of Solutions That existed by 2016 to address Common IoT Challenges

M Abdur Razzaque, M Milojevic-Jevric, A. Palade and S. Clarke "Middleware for Internet of Things: A Survey". IEEE INTERNET OF THINGS JOURNAL: 3(1). Feb 2016

IoT Middleware | Classic Solutions

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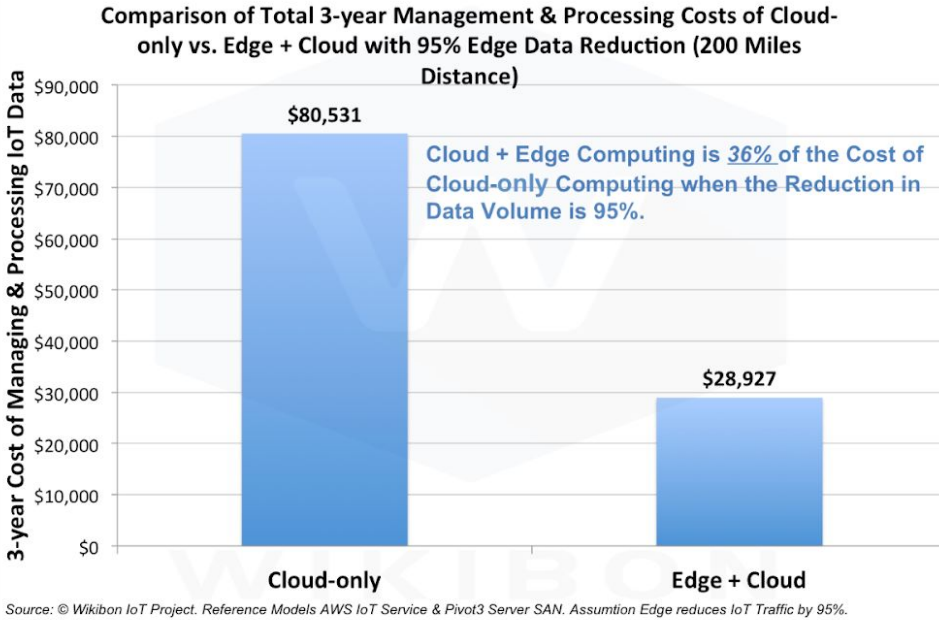
Non Exhaustive List of Solutions That existed by 2016 to address Common IoT Challenges

Limitations of Classic Solutions:

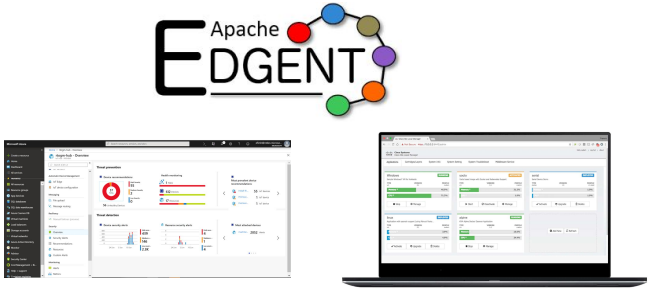
1. Delay
2. Cost
3. Privacy

M Abdur Razzaque, M Milojevic-Jevric, A. Palade and S. Clarke "Middleware for Internet of Things: A Survey". IEEE INTERNET OF THINGS JOURNAL: 3(1). Feb 2016

IoT Middleware | Moving to the Edge



Source: © Wikibon IoT Project. Reference Models AWS IoT Service & Pivot3 Server SAN. Assumtion Edge reduces IoT Traffic by 95%.

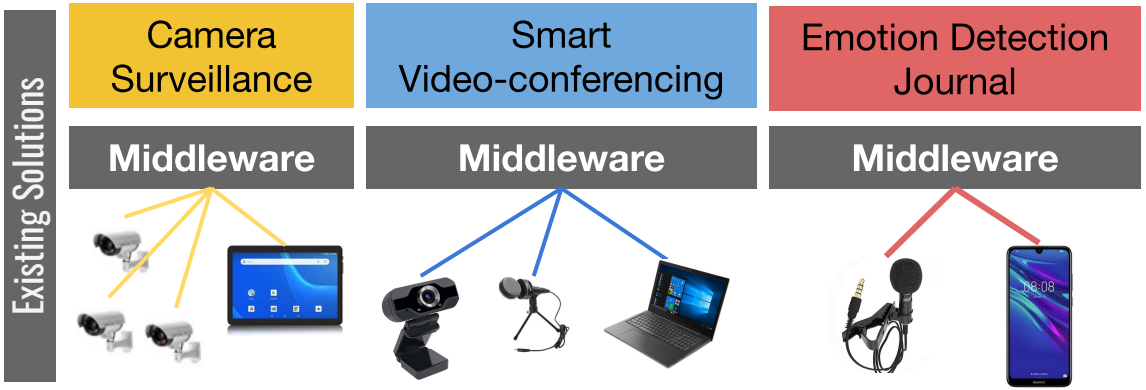


Azure IoT Edge

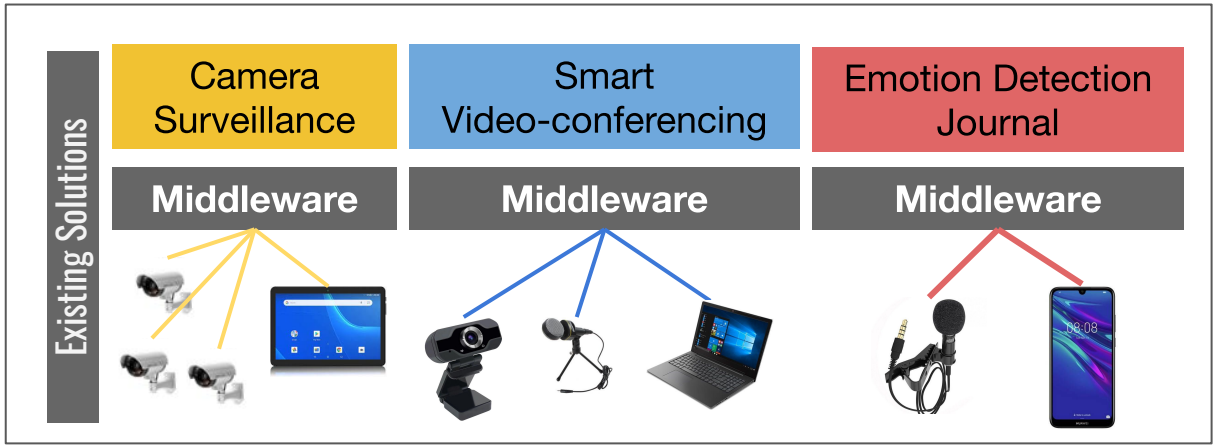
Cisco IOx Edge Solution

Industry Leaders such as Cisco, Apache and Azure started providing IoT Solutions at the Edge

IoT Middleware | What's Next?

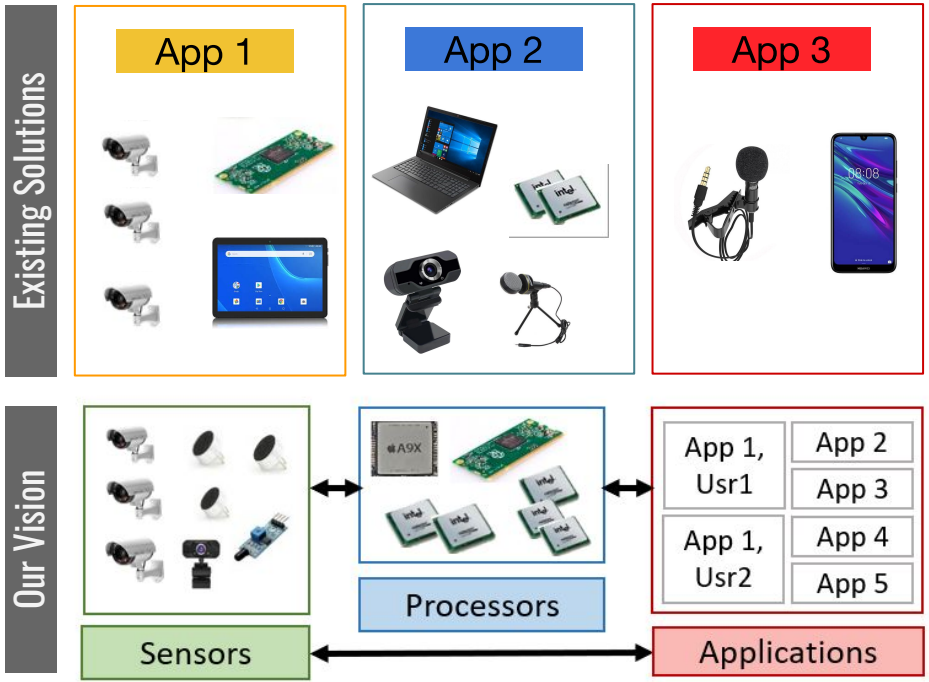


IoT Middleware | What's Next?



IoT Middleware | What's Next?

IoT Middleware | Overcoming the Limit of the Thing

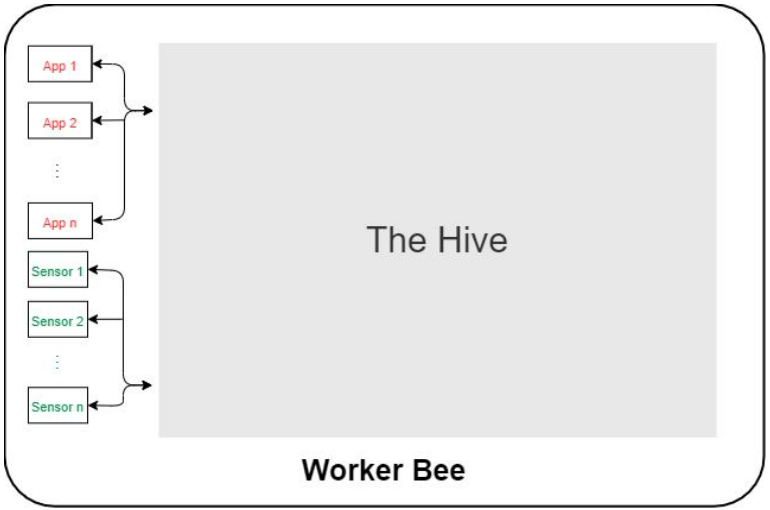


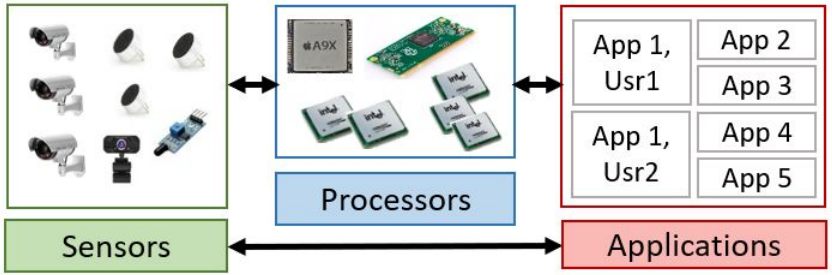
Vision: Develop an IoT Middleware Solution which operates at the Edge which fully capitalizes on the overall resource pool available.

Architecture & Protocol

The Hive Middleware

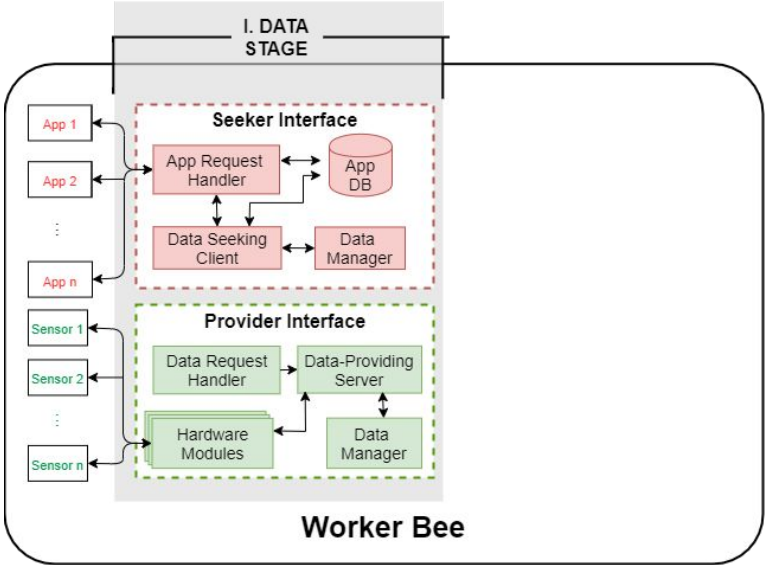
The Hive will interface with applications as well as local resources on a device to create the abstract pools presented in our vision.





Hive Architecture | Seamless Data Exchange

1. Data Stage: Decouple Applications and Sensors



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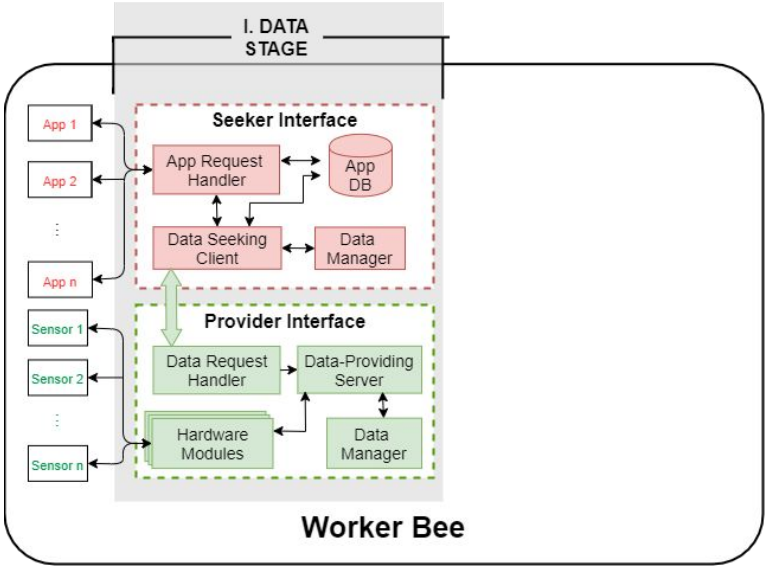
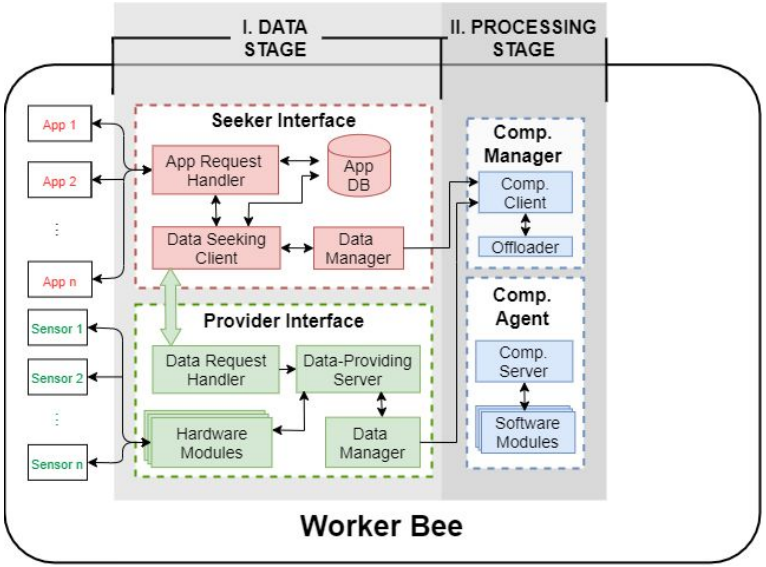


Hive Architecture | Sharing Computational Resources

2. Processing Stage: Decouple processors and devices



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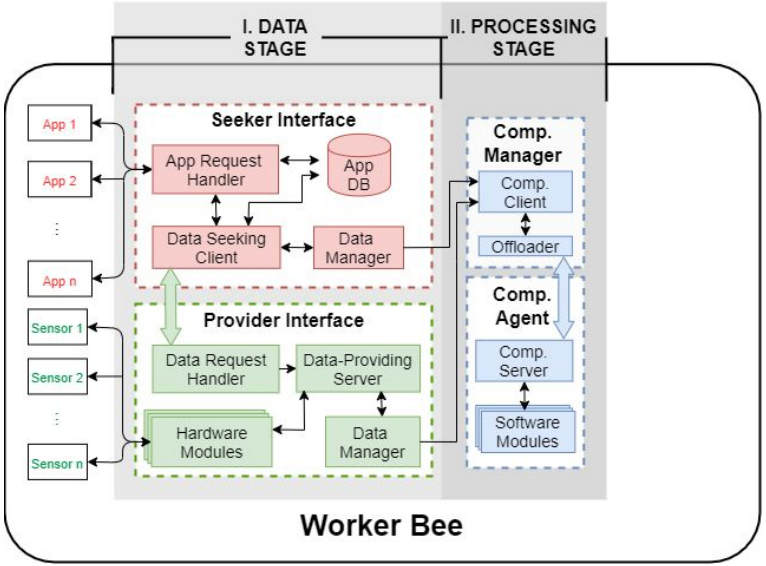
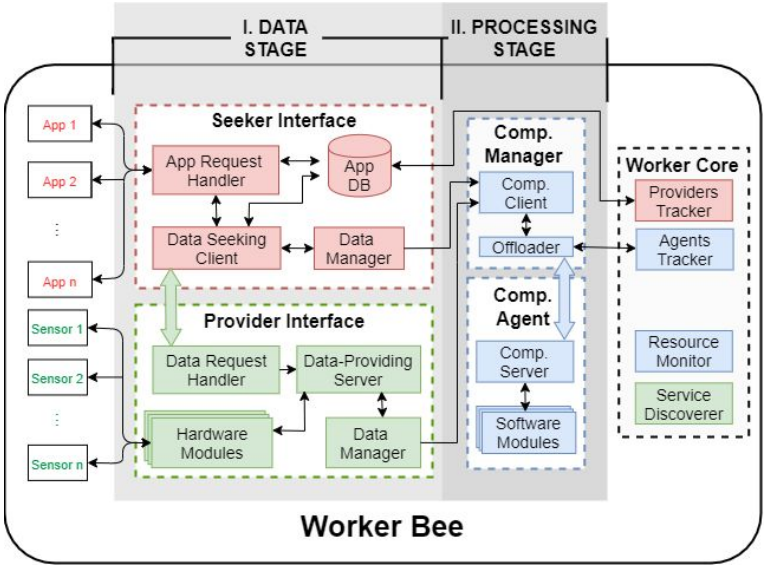
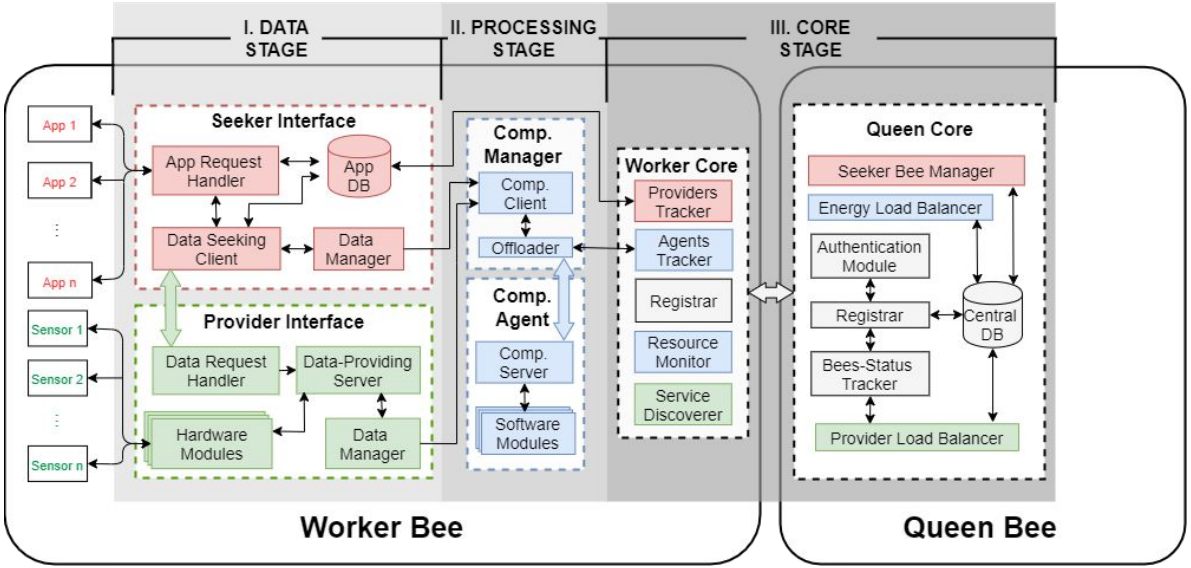


Hive Architecture | Optimizing Resource Utilization



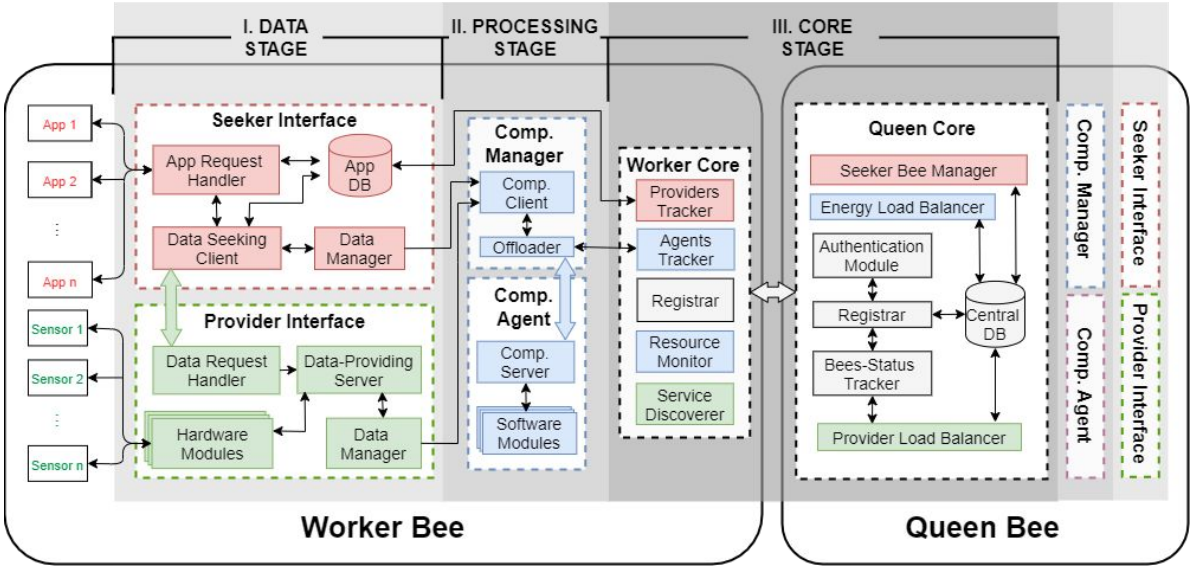
Hive Architecture | Optimizing Resource Utilization

3. Core Stage: Connect the decoupled elements in an optimal manner



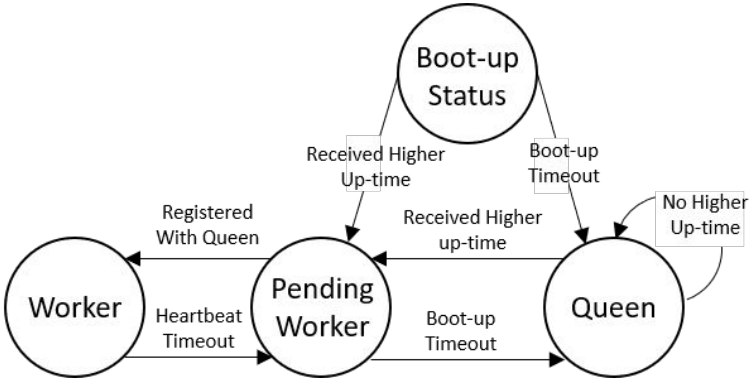
Hive Architecture | Optimizing Resource Utilization

Queen Bee will also have the regular architectural components, since it is simply one of the functional devices of the Hive.



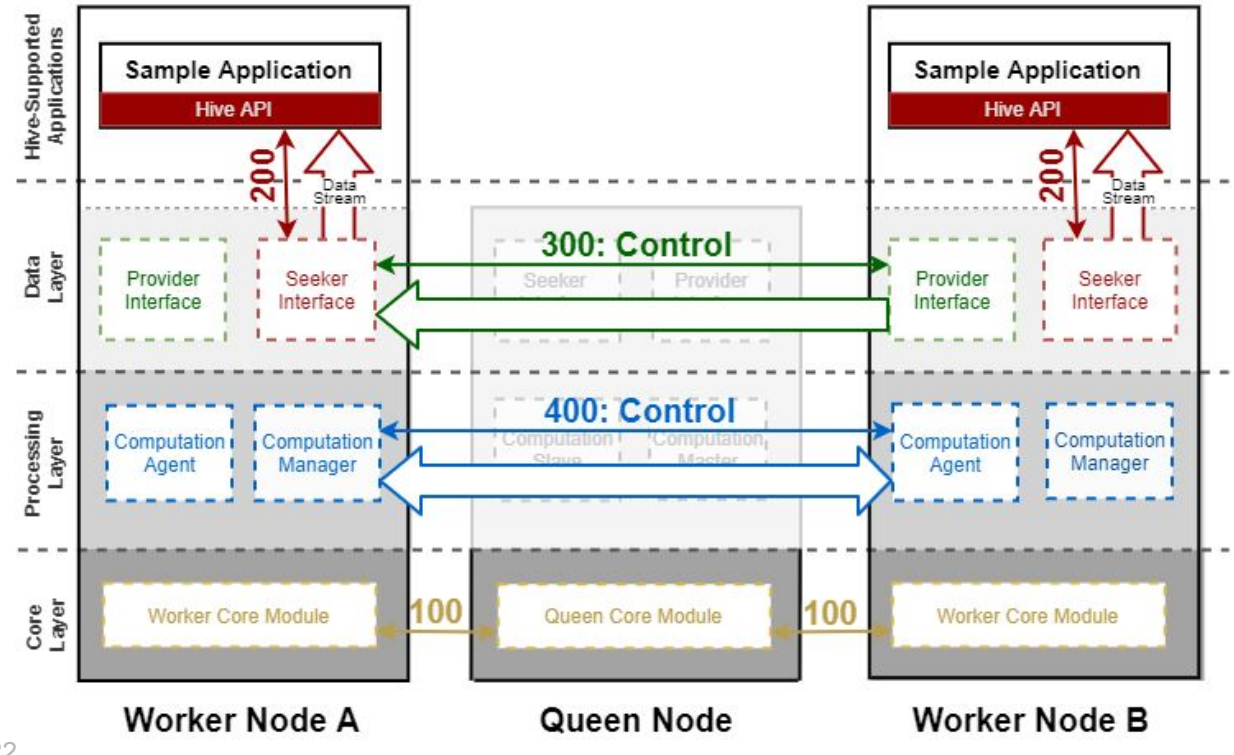
Queen Election

- Distributively elected node
- First come-first-serve basis
- In case of a tie, the algorithm selects the Queen with the highest up-time



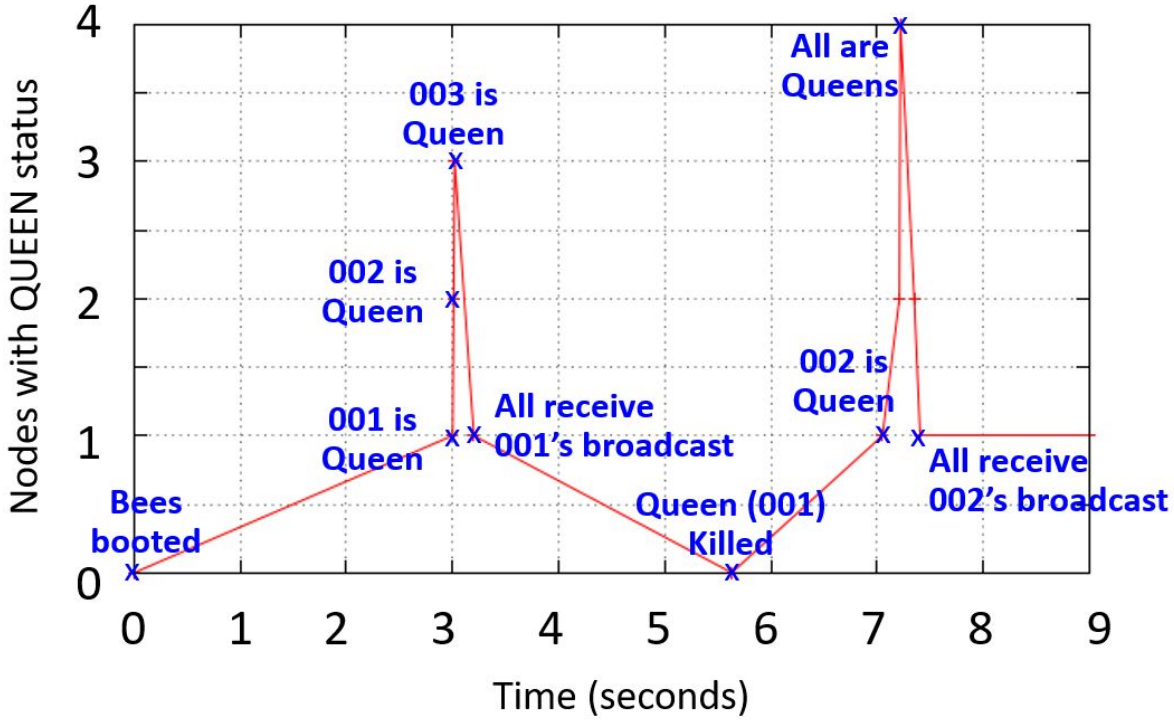
Queen Election Process State Machine based on our variation of a classic distributed leadership election algorithm

Hive Protocol



Prototype Evaluation

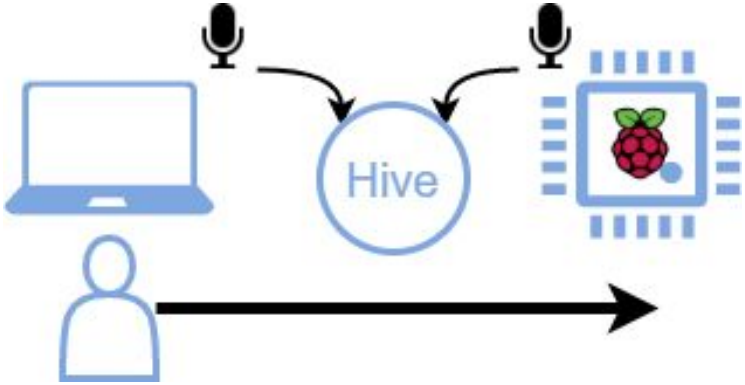
Queen Election

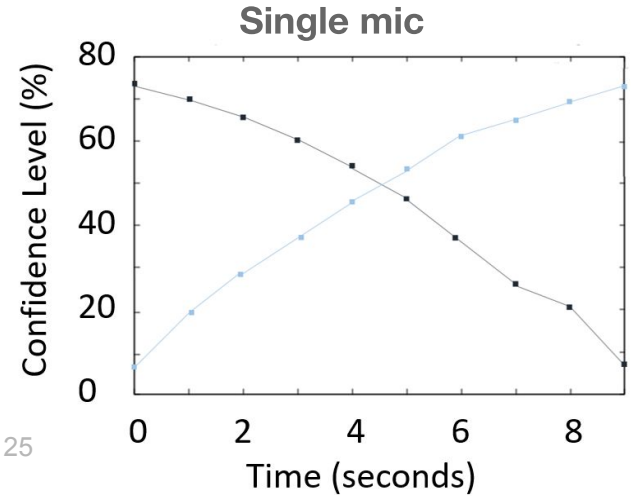


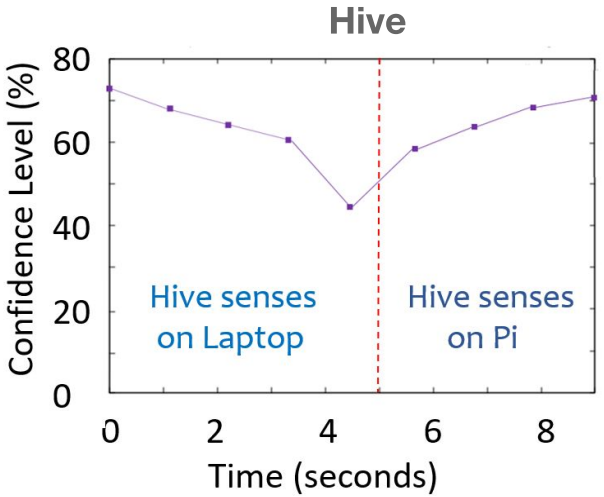
5 Pi's boot up at the same time.

Kill queen to trigger re-election.

Vokaturi on Hive





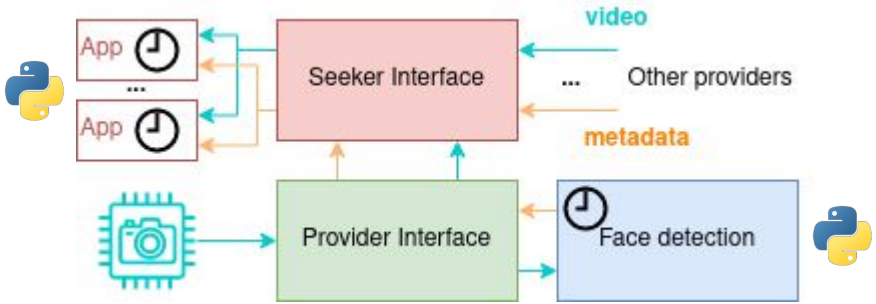


Video Module Implementation

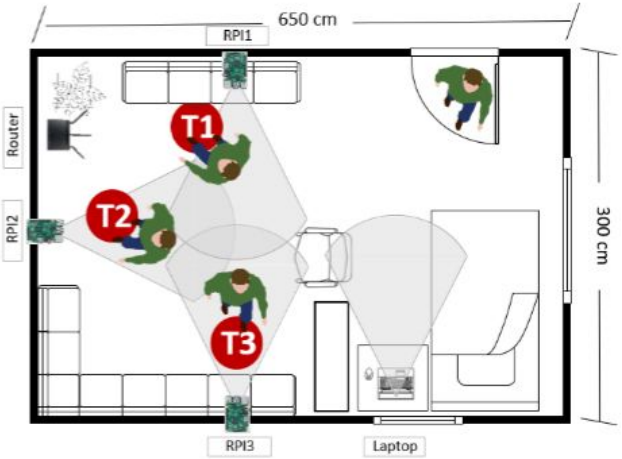
Face detection software module in OpenCV.

Seeker picks stream with highest confidence.

Timing from detection to app, with NTP.



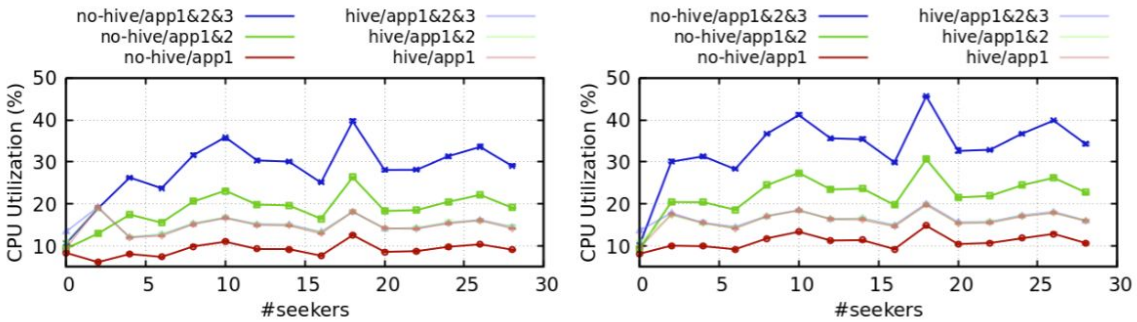
Best Face View



Resource Usage

Streaming from camera to many apps on the same device.

Detection algorithm runs once in Hive, vs. once per app without hive.

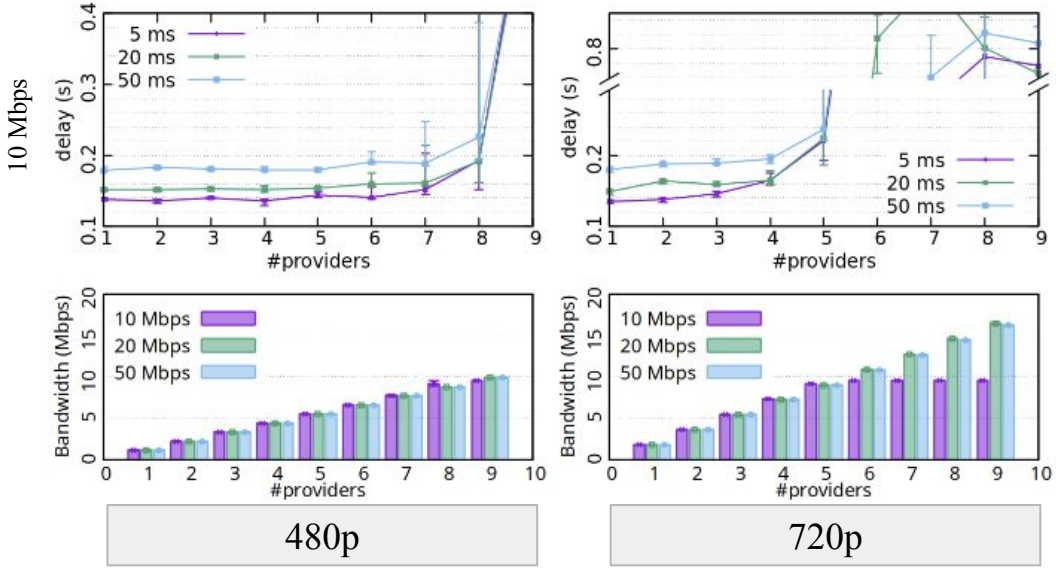


Scalability

Many seekers, one provider.

Breaks when bandwidth exceeded

Similar results for one seeker, many providers.



Conclusion

Conclusions

Existing frameworks do not utilize the full potential of IoT.

Decoupling applications, sensors and processors using the a generic Architecture and Protocol like the Hive's can

1. overcomes these limitations
2. enable a new generation of host-independent apps.
3. saves costs while introducing minimal overhead

Thank You.

For questions and comments, please contact us on:

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