ETH
Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

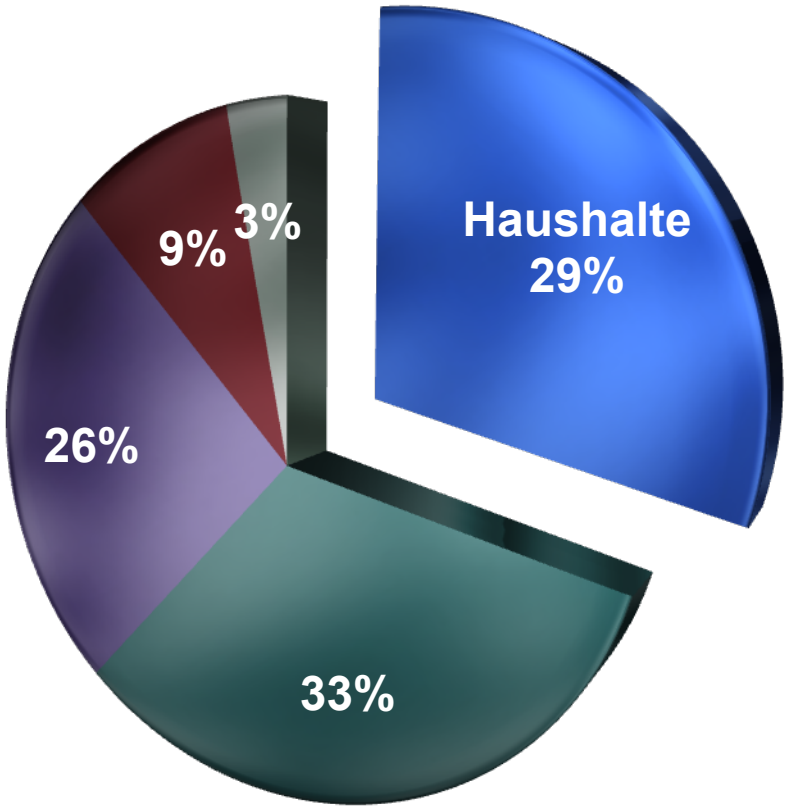
inf | Informatik
Computer Science

Überwachung des Energieverbrauchs auf Geräteebene: verteilte und hybride Systeme

Fabian Aggeler (aggelerf@ethz.ch)

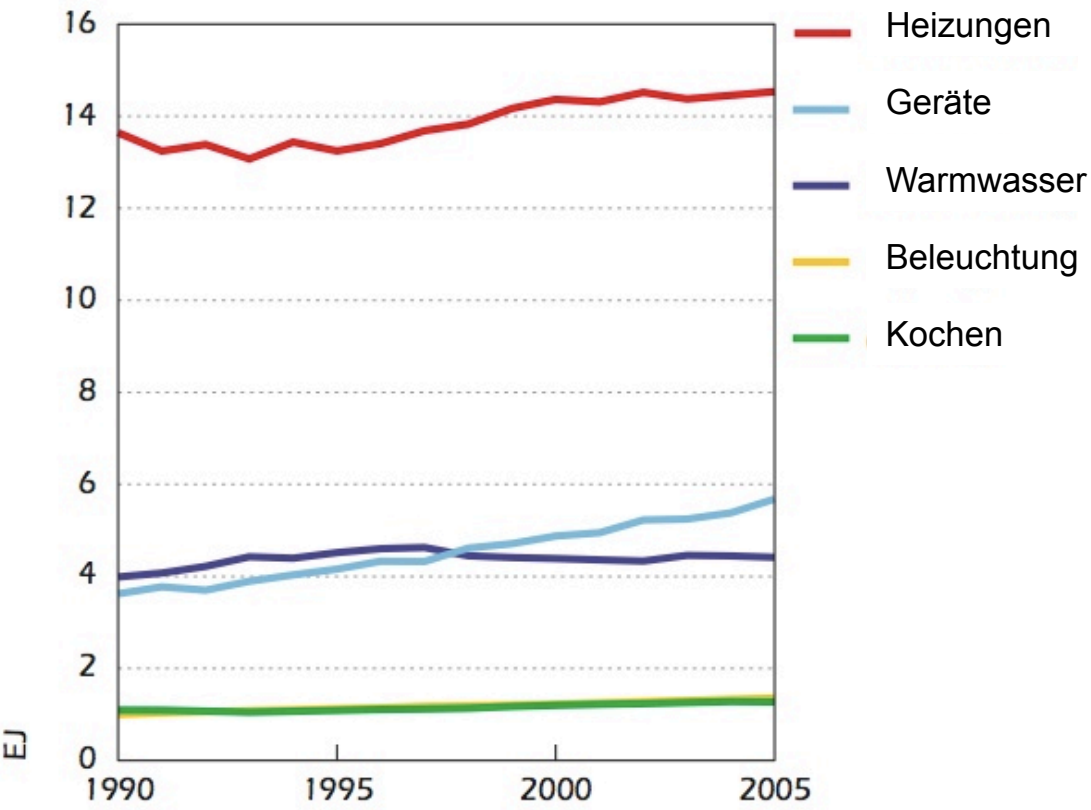
Energieverbrauch in Sektoren

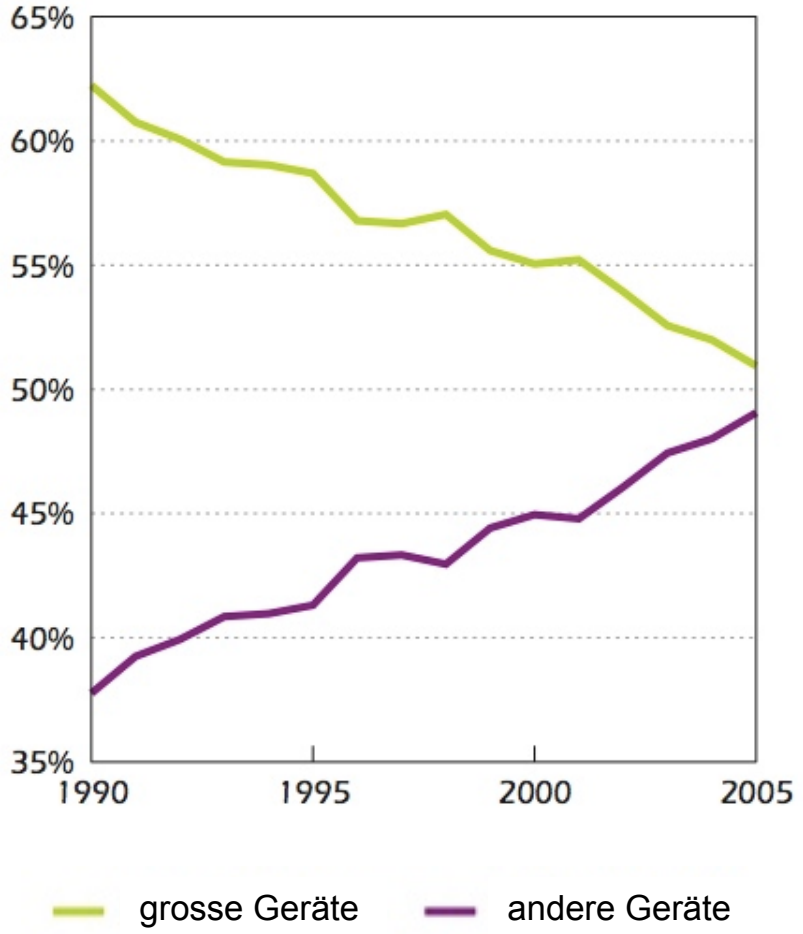
- Haushalte
- Industrie
- Transport
- Dienstleistungssektor
- andere



Quellen: IEA, 2007c; IEA, 2007d; IEA, 2007e

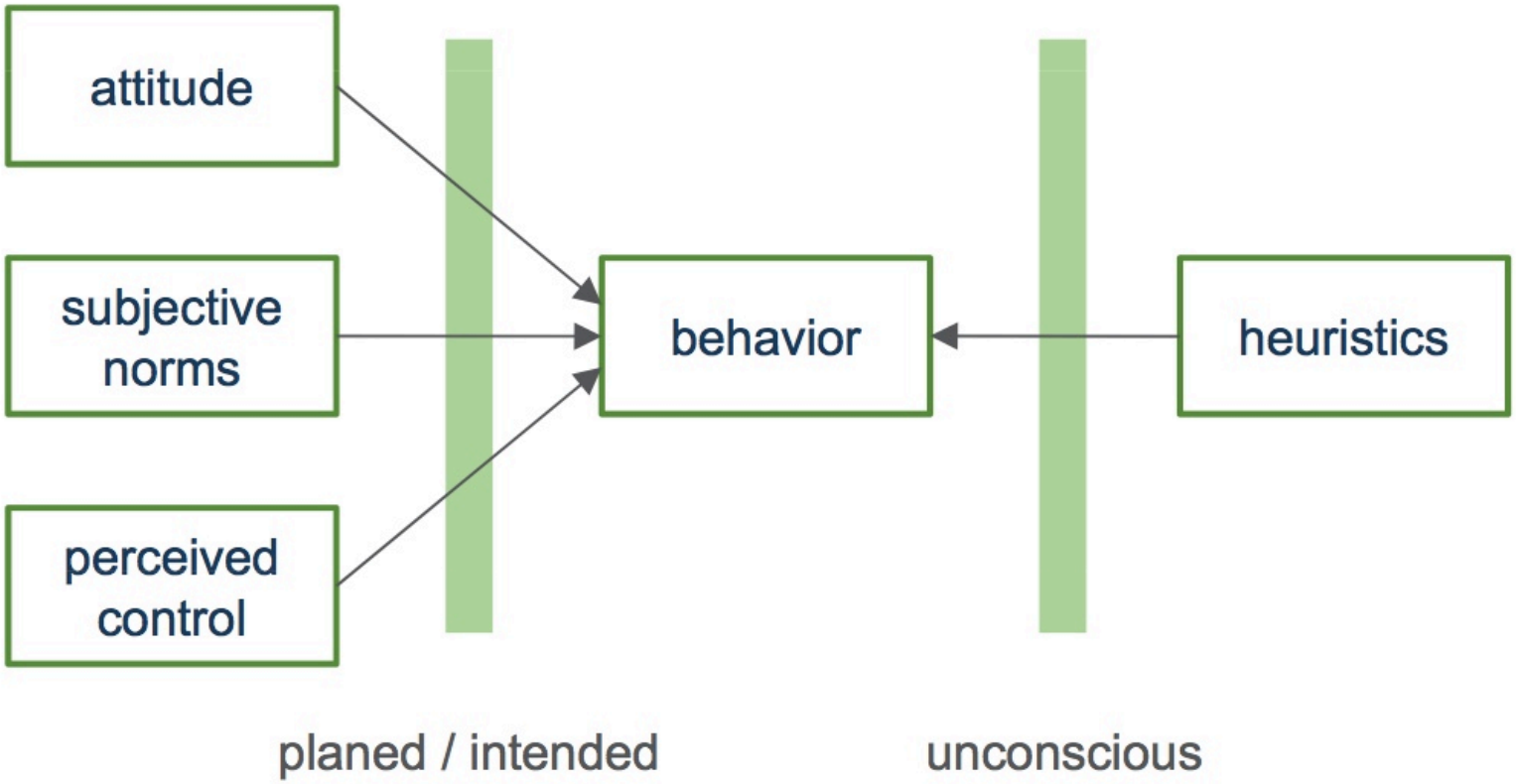
Trends





Quelle: IEA - Worldwide Trends in Energy Use and Efficiency

Verhaltensmodelle: Theorien mit Bezug zur Verhaltenswirksamkeit von Informationen



Quelle: Aizen (1991)

Inhalt

- Related Work
  - Kommerzielle Systeme
  - Datenrepräsentation
  - Engagement Strategies
- Feedbacksysteme auf Geräteebene
  - zentralisierte Systeme
  - verteilte Systeme
  - hybride Systeme
  - Vergleich
- Konkrete Implementierungen
  - digitalstrom
  - ViridiScope

Kommerzielle Systeme: Wattson

Preis: £99.95

Quelle: Toby Summerskill/ DIY KYOTO

Kommerzielle Systeme: CLICK

Preis: CHF 89.-

Quelle: EKZ (http://www.ekz.ch/internet/ekz/de/ueberuns/100_jahre_ekz/click.html)

Kommerzielle Systeme: ARP PM230

Preis: CHF 39.-

Quelle: ARP Datacon AG (http://www.arp.com/)

Datenrepräsentation

Quellen: eMeter (www.vs.inf.ethz.ch) / Google PowerMeter (www.google.org/powermeter/)

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Datenrepräsentation [2]: Technologie nicht genug

- Zusammenzählen oder Runterzählen?
- Tag oder Jahr?
- Ziel setzen
- Passende Vergleiche
- Öffentlichkeit

Engagement Strategies

- Real-Life Game
- Push-Meldungen
  - Cross-Selling
  - Alarm
- Flexibilisierung der Tarife

Feedbacksysteme auf Geräteebene: Unterteilung

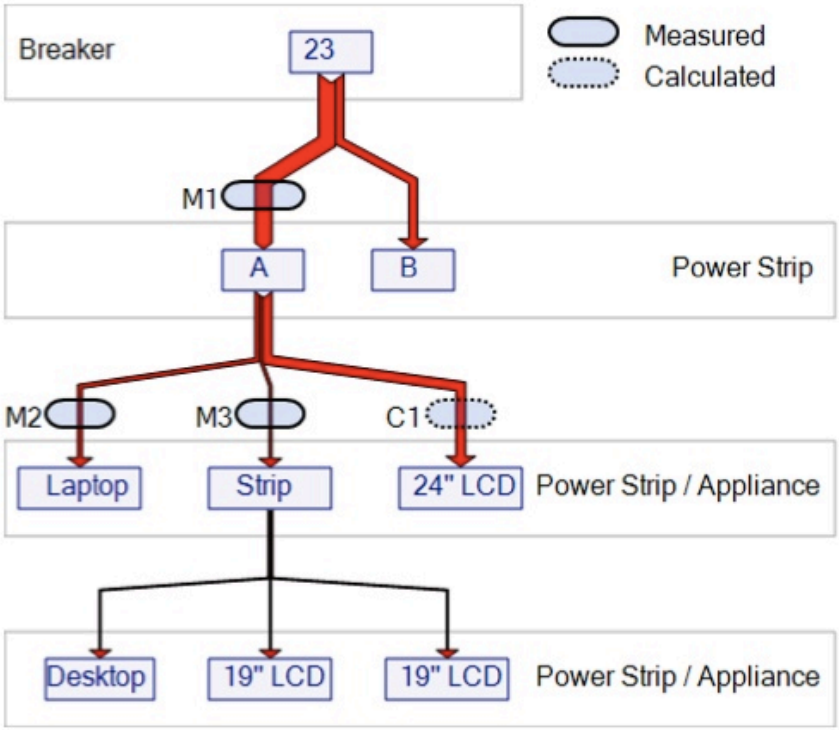
- Zentralisierte Systeme
- Verteilte Systeme
- Hybride Systeme

Zentralisierte Systeme

- ein zentraler Strommesssensor
- Ansicht: gesamter Stromverbrauch
- Geräte messen:
  - Ein-/Ausschalten
  - Signaturen

Verteilte Systeme

- viele auf Geräte verteilte Stromsensoren
- Ansicht: Pro Gerät/ Gerätegruppe und Gesamtverbrauch
- Hohe Genauigkeit

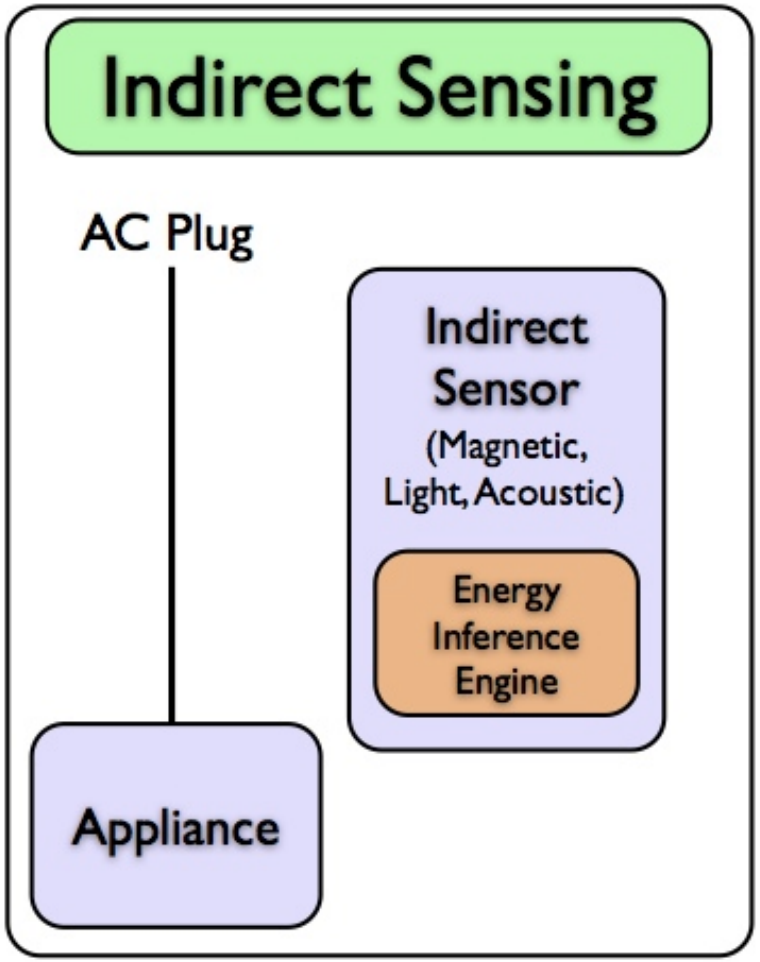


Quelle: X. Jiang et al., Experiences with a High-Fidelity Wireless Building Energy Auditing Network

Hybride Systeme

- ein zentraler Stromsensor
- viele Kontextsensoren
  - Magnetsensor
  - Akkustiksensor
  - Lichtsensor
  - usw.

- Ansicht: Gesamtansicht und Pro-Gerät
- Kompromiss: Genauigkeit / Vollständigkeit



Quelle: Y. Kim et al., ViridiScope: design and implementation [...], ACM, 2009

Vergleich der verschiedenen Systeme

Character-istics	Single sensors	Multiple sensors	
		Direct in-line	Indirect
Installation	Hard	Medium	Hard
Cost	Low	High	High
Usage barrier	Low	High	High
Calibration	Hard	Easy	Hard
Device level accuracy	Low	High	Medium
Household level accuracy	High	Low	High

Quelle: Mattern et al., ICT for green - how computers can help us to conserve energy, 2010

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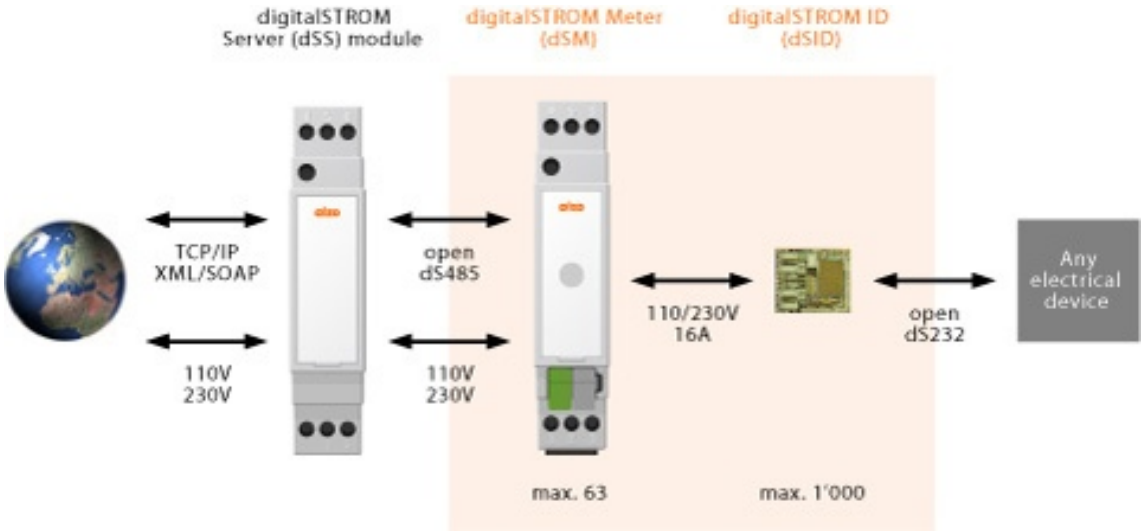
Konkrete Implementierungen

- digitalSTROM®
- ViridiScope

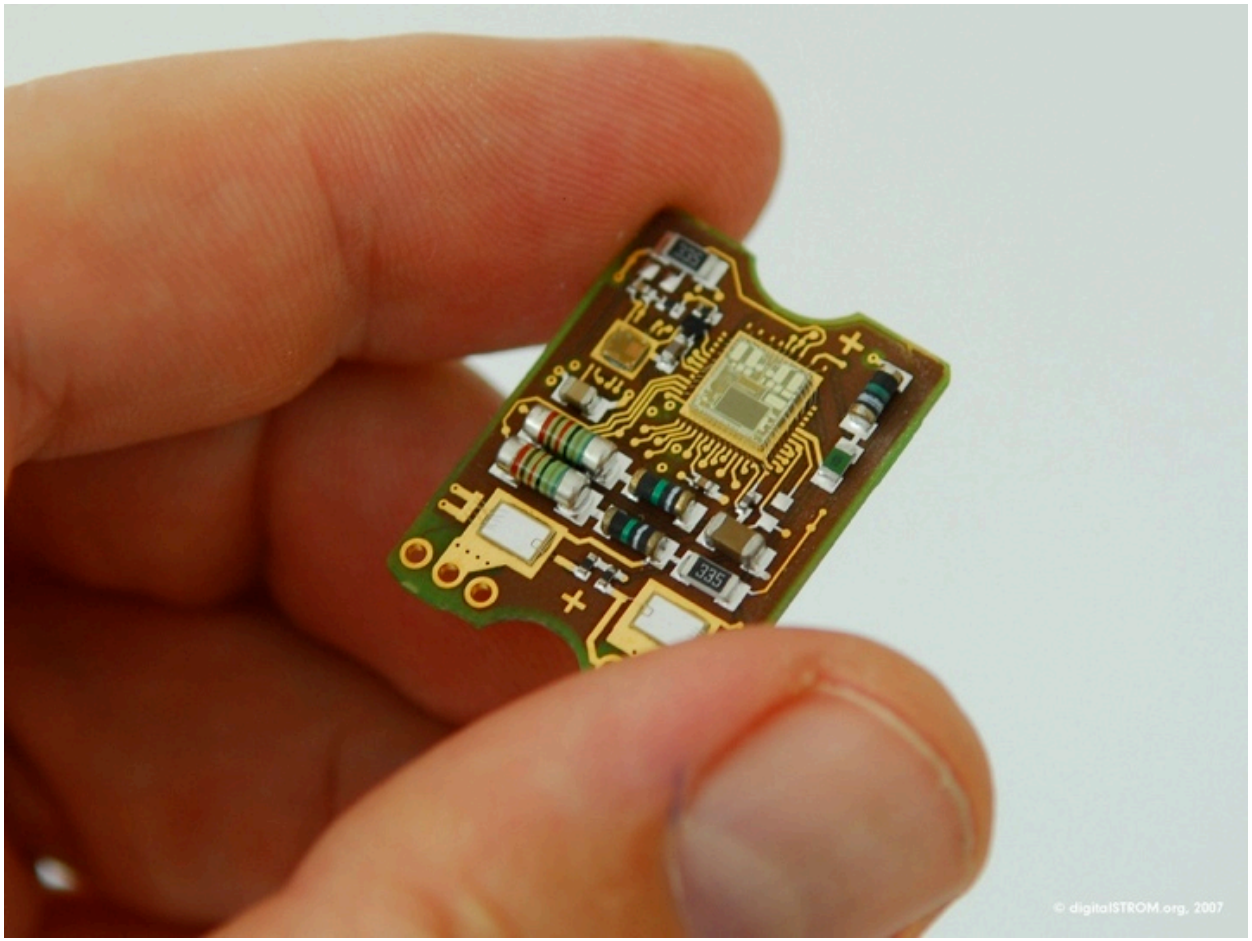
digitalSTROM (seit 2007)

- dSID (Hochvoltchip)
- dSM (Meter)
- dSD (Komponenten)
- dSS (Server)



Quelle: aizo ag (www.aizo.com/de)

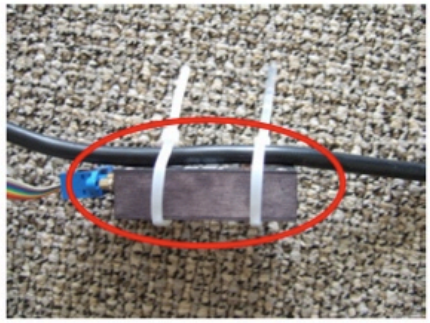
digitalStrom [2]: Technik



Quelle: aizo ag (www.aizo.com/de)

ViridiScope (2009)

- Universität Los Angeles: Younghun Kim et al.
- Herausforderungen:
  - Platzierung
  - “in-situ” Kalibrierung
  - Rauschen der Umgebung filtern



Magnetic Sensor Strapped on Power Wires

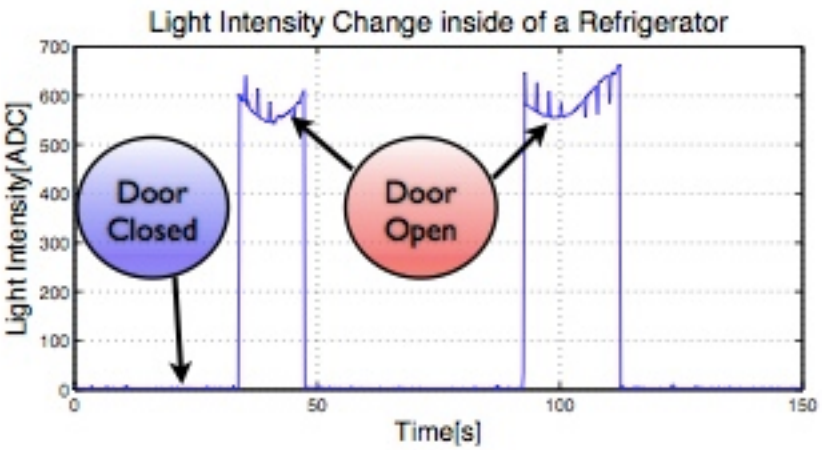
Television Screen

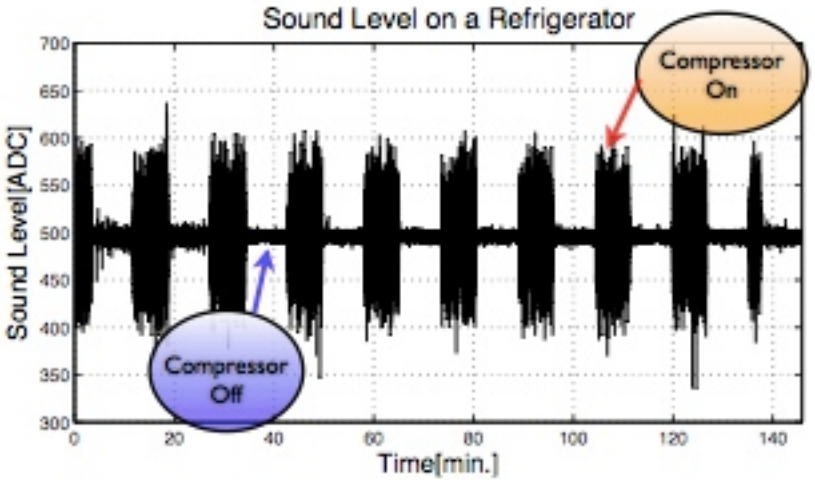
Refrigerator

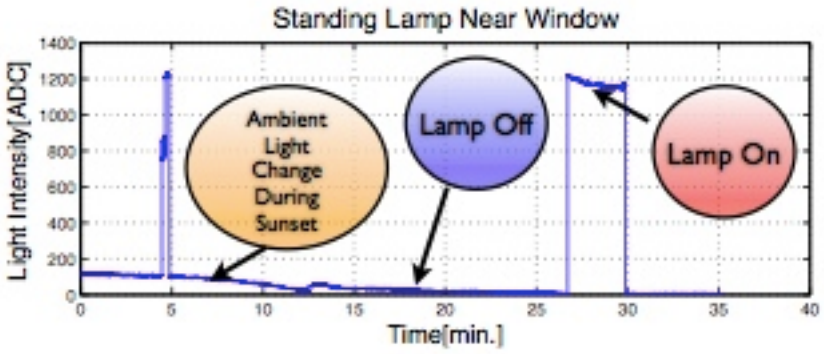
Standing Light

Quelle: Y. Kim et al., ViridiScope: design and implementation [...], ACM, 2009

ViridiScope [2]: Ereignisse aus Sensordaten







Quelle: Y. Kim et al., ViridiScope: design and implementation [...], ACM, 2009

ViridiScope [3]: Kalibrierung

$$min \left\| y_0(t) - \sum_{i=1}^{N} p_i(t) \right\|$$

$$p_i(t) = \begin{cases} \alpha_i s_i(t) + \beta_i : \text{Magnetsensoren} \\ \sum_{j=1}^{K_i} P_{i,j} s_{i,j}(t) : \text{Licht/Akkustik Sensoren} \\ P_i s_i(t) : \text{unbestimmter Restverbrauch} \\ \tilde{p}_i(t) : \text{direkt gemessen} \end{cases}$$

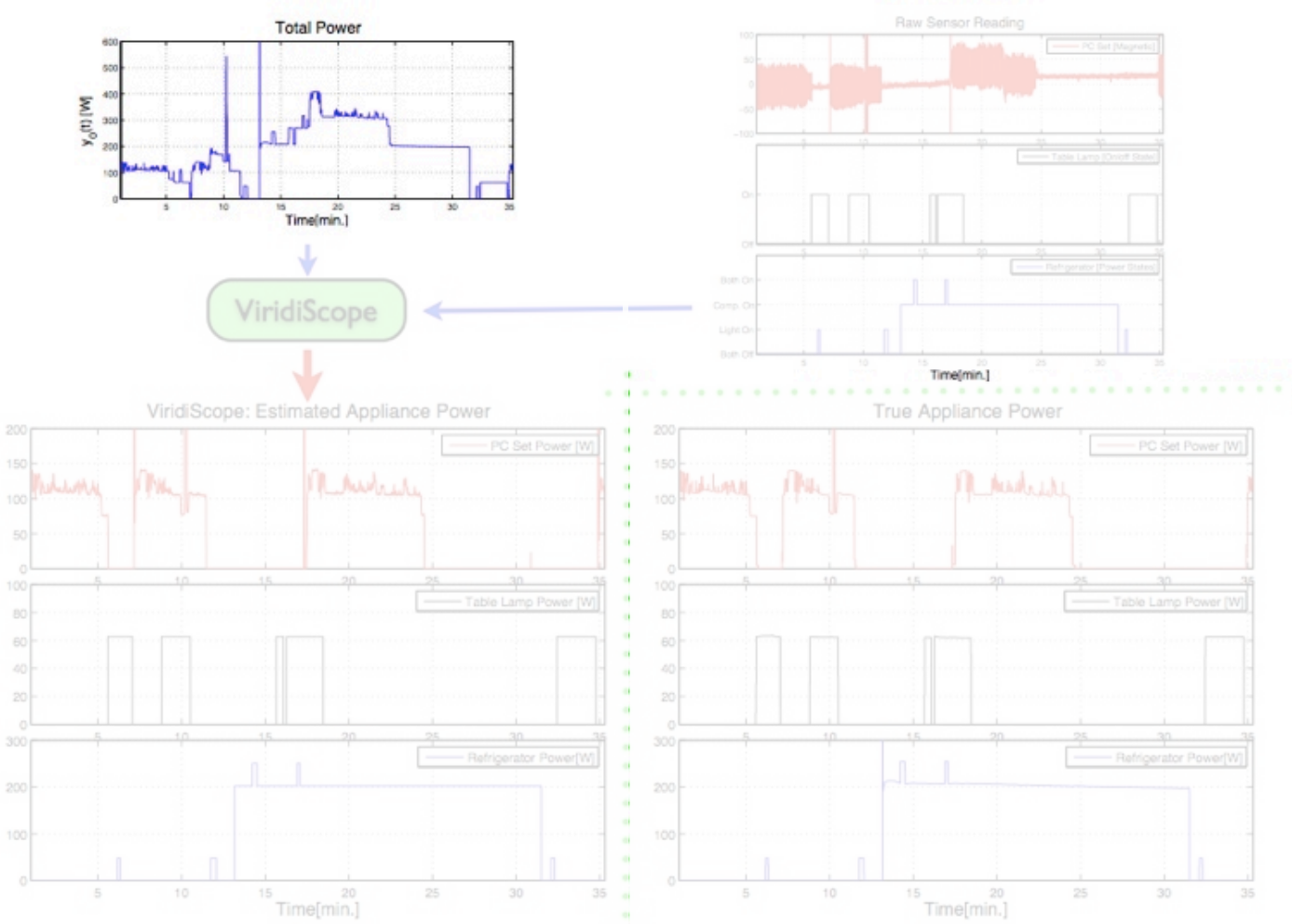
Legende:

$y_0(t)$: gesamter elektrischer Energieverbrauch

$s_i(t)$: Signale von Sensoren

$P_{i,j}(t)$: Durchschnittlicher Stromverbrauch des Zustands j von Gerät i

ViridiScope [3]: Resultat



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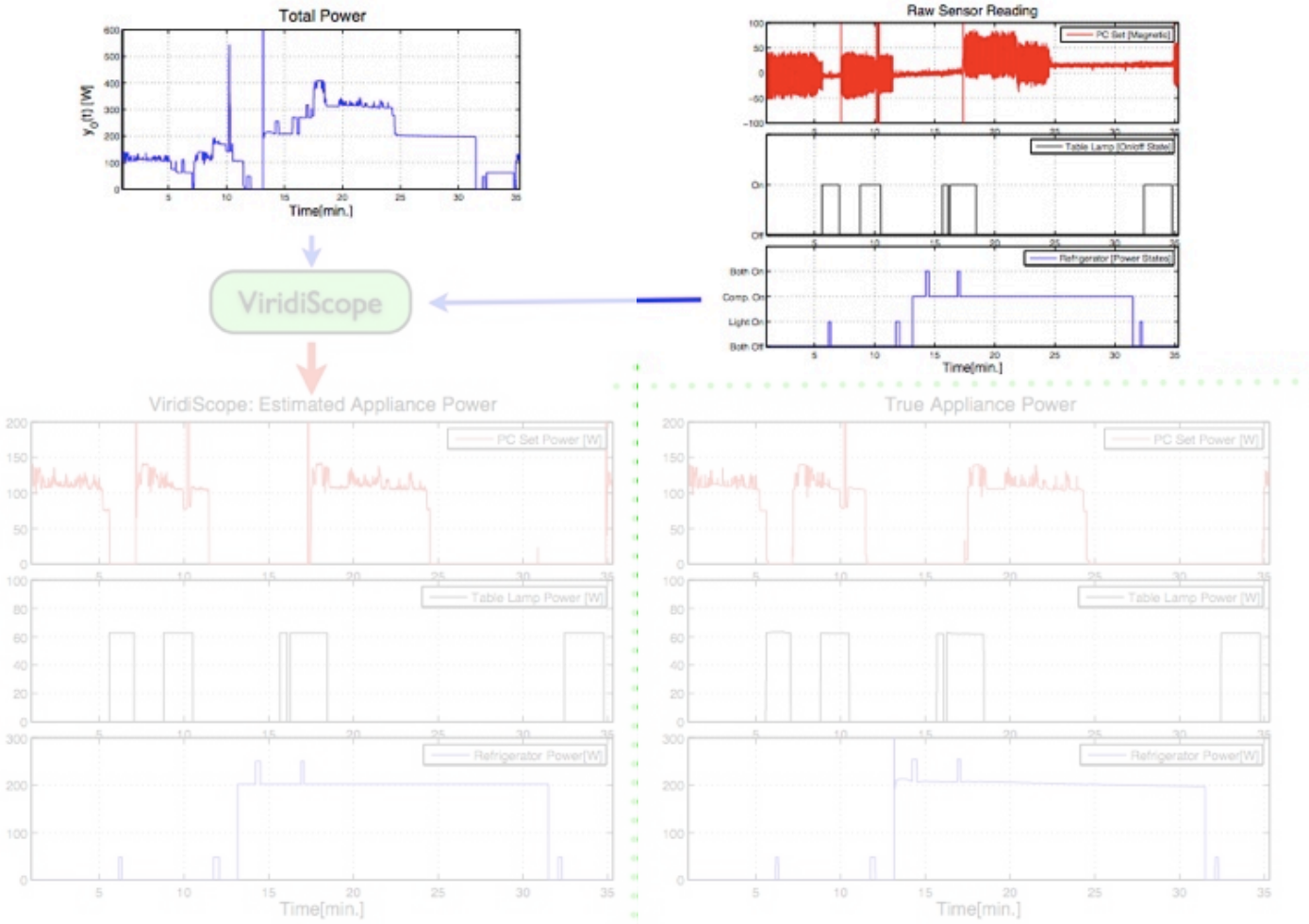
ViridiScope [3]: Resultat



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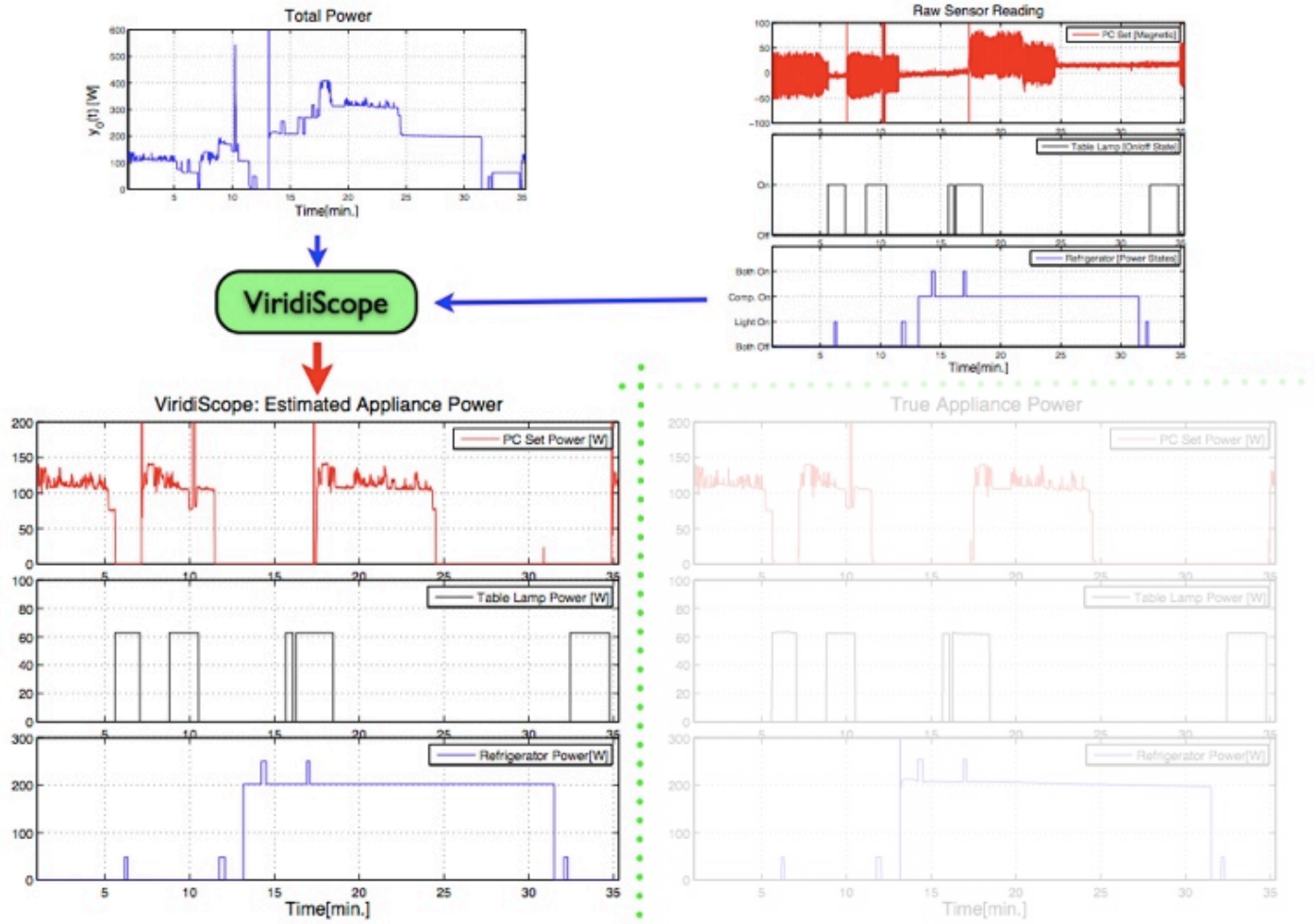

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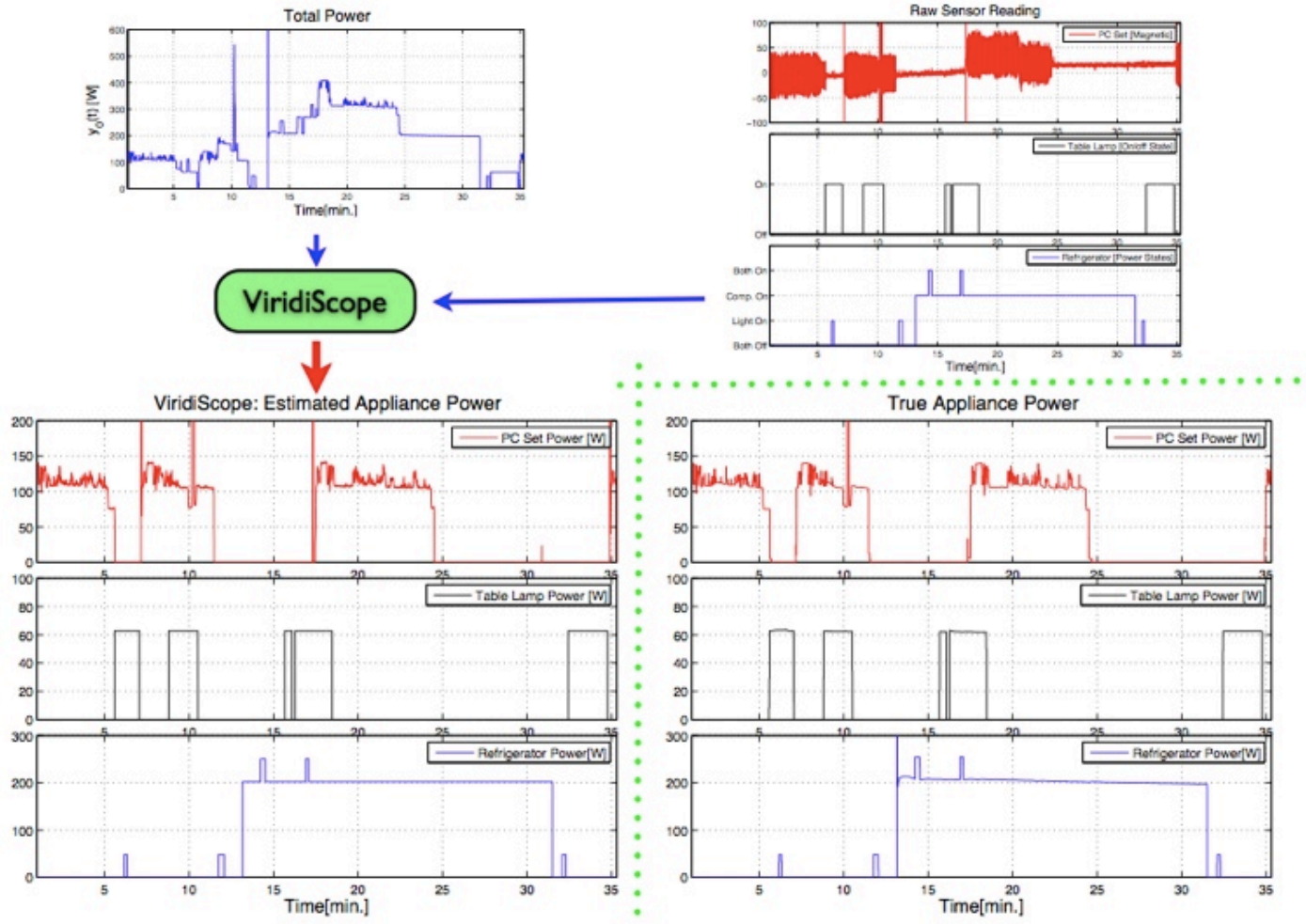

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Schlusswort

- Transparenz wichtig für Einstellung und somit Verhalten
- Datenrepräsentation & Engagement Strategies
- verschiedene Ansätze (zentralisiert, verteilt, hybrid)
  - Vorteile / Nachteile: Trade-Off
- Noch kein marktreifes Produkt erhältlich
  - jedoch vereinzelte Lösungsansätze
- Vision: jedes Gerät beinhaltet schon einen Strommesssensor